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POWER

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The Integration of our Power Supply

WHEN a community is young, each household has its well or spring and the town pump is the limit of communal effort in the direction of water supply.

As the population becomes more dense, such local supplies become contaminated and inadequate and a collective system is instituted, either by the municipality or by a group delegated by franchise to perform the service.

The safety and convenience of running water conductible anywhere is secured, and as the community grows and the demand increases, the best thought and knowledge and experience that can be commanded is focused upon the appraisal of conditions concerning a future supply and a scientific engineering study made of available watersheds and the best way of conserving, collecting, conveying and distributing the water that falls upon them that the danger of a drought may be avoided and the attainment of the limit to growth from lack of water deferred as long as possible.

The unorganized, inconvenient, cumbersome and inefficient condition of individual supply has passed into a highly organized, systematic and expert effort to make the best use of available resources.

In the matter of power we are just emerging from the primitive individualistic stage.

The machinery installed by central stations for the collective furnishing of electricity for lighting purposes can be kept running through the day and supply current for power.

The improvement in range and efficiency and dependability of transmission systems, the development of the electric motor and a host of electrically operated appliances have made power accessible in all sorts of places and replaced human by mechanical effort in many industrial and domestic processes.

Even now the smaller and less efficient central stations are being abandoned and their load supplied from better designed and situated base-load plants.

It is not too early to undertake a serious consideration of what all this is leading to and, with wise foresight and expert engineering, study our power resources with a view to their intelligent and rational collective development, unhampered by conflicting interests or any other consideration than the greatest public good.

The great system into which the power supply of the country would thus be integrated would of necessity be a monopoly, and its effective regulation should not be hampered by the fact that it transcends state boundaries, nor confined only to the distributor who deals directly with the public to the exclusion of the station which produces and sells in bulk. Such regulation should not be so stringent as to discourage legitimate investment and should be sufficiently flexible to stimulate initiative, research and zeal in the strife for greater efficiency. And such a system should offer the opportunity for the tying into it of the still numerous plants which, because of their requirements for exhaust steam for heating and industrial processes, can run to advantage their own power plants more or less of the time.

F. R. Low

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X-Ray Investigation of Steel Castings for Advanced Steam Conditions

By F. H. MOREHEAD
Assistant Chief Engineer, Walworth Manufacturing Company

THE efforts of designing and operating engineers to secure increased efficiency by raising pressures and temperatures are limited only by the lack of a proper material for the control of the moving fluids. The question therefore arises, How can we know in advance that products recommended for this service will continue to withstand the resulting molecular bombardment?

It is imperative that there be developed an authoritative test by which absolute knowledge of the internal integrity of the material may be determined in advance. Manufacturing processes of such a nature that uniform integrity is assured should be set up. The results obtained from such a test, the defects thereby uncovered and the remedies applied are important in relation to progress in steam pressure and temperature.

The tremendous hazard to life and property incident to the control of fluids under high-pressure, high-temperature conditions is fully appreciated. The futility of routine tests for physical properties by the use of various test coupons, either cast separately or attached to castings, is also recognized.

There is little assurance that the physical properties developed in the test bar are present in the casting, and removal of test specimens from the casting itself destroys that casting and gives no guarantee that the surrounding material is of equal quality. An occasional investigation of a casting by the removal of sections for metallurgical examination gives little knowledge of its integrity because the observations are limited to the particular section open to view.

It is therefore evident that some method must be sought which, when properly applied and intelligently interpreted, would show without doubt whether the casting possesses the same degree of excellence as the test bar, not at some particular point but throughout its mass. It was desired to use the proposed test as a means of locating defects if any were present and, having located and identified them, to apply corrective measures for their elimination.

Such an investigation was made by the Ordnance Testing Laboratory at Watertown Arsenal, Col. T. C. Dickson, Commanding Officer which, under certain conditions may do work for industry. This laboratory is under the supervision of F. C. Langenberg. The X-ray section is directed by H. H. Lester.

A Coolidge tube of the usual medical type, except for size, is used. The walls and ceiling of the X-ray laboratory are lead-covered for the protection of the operator and others who may be in the vicinity. The door is provided with a safety switch which prevents illumination of the tube until the room is closed. An impressed voltage up to about 280,000 can be used and a thickness of about three inches of metal thus penetrated. A typical casting in place is shown in Fig. 1. Note the plate holder inside the sample ready for exposure.

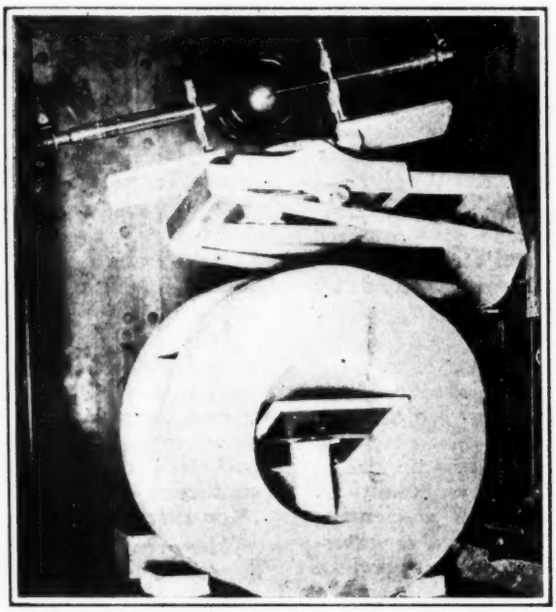


Fig. 1—Coolidge X-ray tube above the casting and plate holder within

Sample tee castings were produced according to the practice then in effect and submitted to the laboratory for investigation. These were subjected before shipment to a routine foundry test of 100 lb. per sq.in. air pressure with a film of soap and water. No leaks developed. No defects appeared on the surface, as can be seen at *D*, Fig. 2.

The tees were produced in electric acid-lined furnaces. Numbers were painted in the centers of areas to be examined, and photographs were taken so that the location of exposures could be fixed at any time. Before an exposure was made, lead numbers were laid directly over the painted ones so that the numbers appear on the X-ray film or plate.

A typical film is shown at *H*, Fig. 2, selected from this first series of tests. Many types of defects are thus disclosed. The real value of the research lies in the reading of the films by the laboratory, which are carefully checked for defects in the films themselves and for surface inequalities in the casting. Dark spots and lines indicate voids or inclusions of materials less dense than steel, hence overexposure of the film at this point.

The most careful check failed to disclose any surface indication of the hidden defects. Test bar and chemical records of the various heats represented, indicated excellent steel. Here then was proof positive that test-bar data could not be taken as representing casting conditions.

After the films had been carefully recorded, the

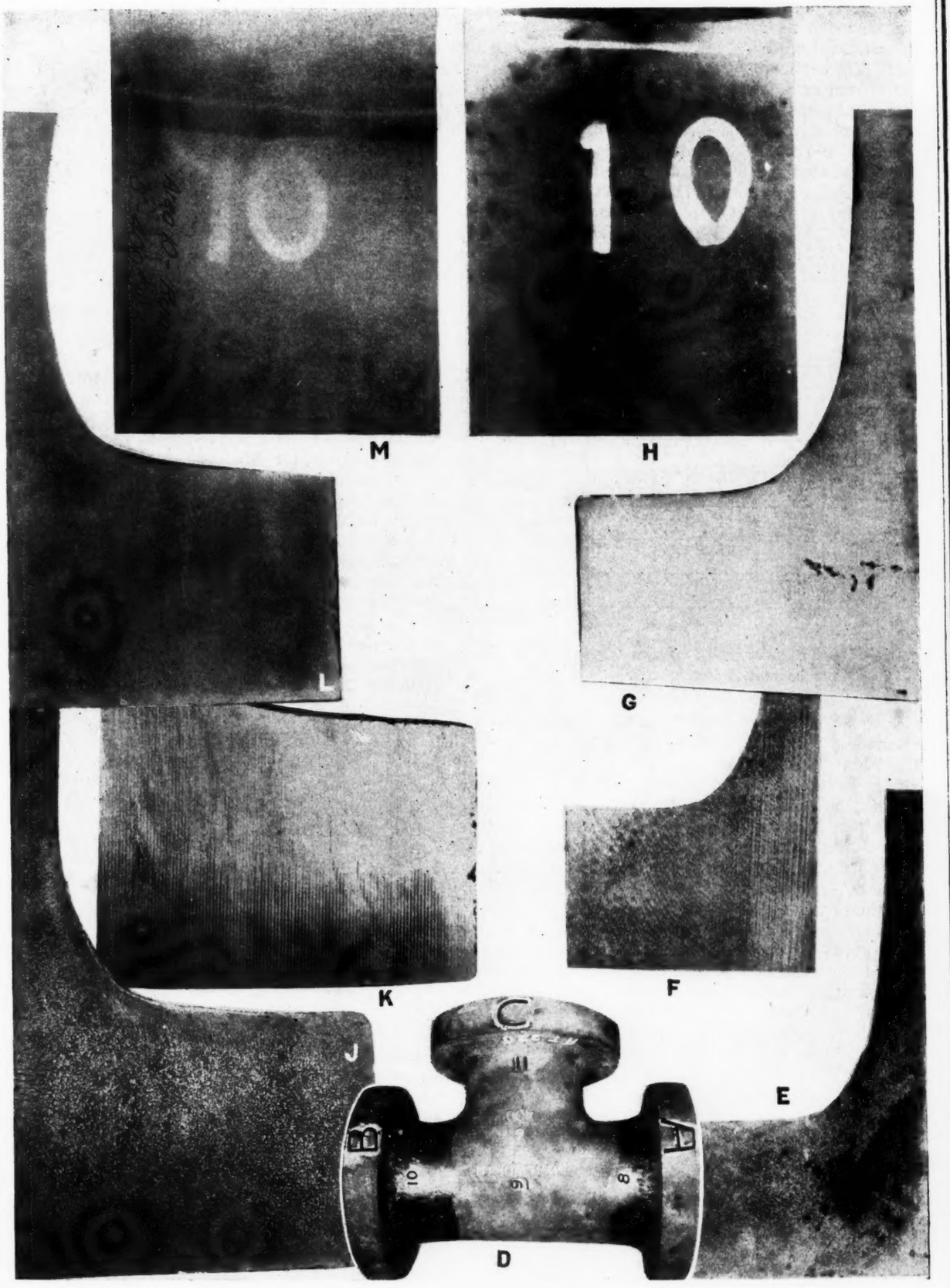


Fig. 2—Dirt inclusions shown at right; uniform improved steel at left. H and M are X-rayed through fittings. Sections F and K are polished, E and J etched, G and L X-rayed

casting was sectioned. A photograph of one ground section appears at *F*, Fig. 2. The sections indicated one large inclusion near the surface close to the flange of this casting, but otherwise the metal appeared clean and sound. The section at *F* was then exposed to the X-ray, as at *G* and macro-etched, *E*, thus indicating the lack of density in the center of the section.

The next step was a series of conferences at the laboratory and at the foundry. Gates, risers, sands, binder, patterns, molding and coremaking practices were closely scrutinized. The benefits derived from this scrutiny are best shown on the series of examinations as at *J*, *K*, *L* and *M*, Fig. 2. Many areas were X-rayed as at *M*, their locations with respect to the tee being identified by the corresponding numbers. Thus

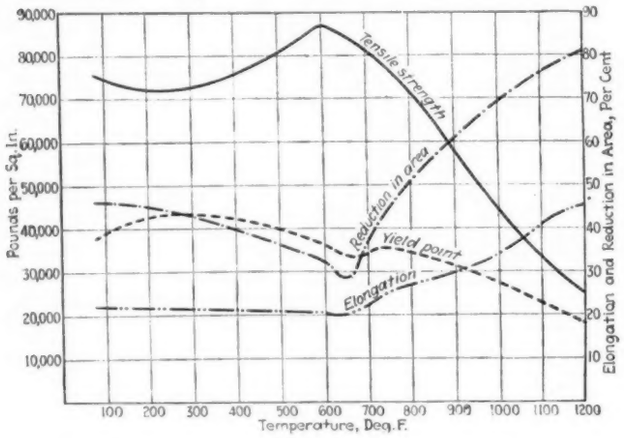


Fig. 3—Physical properties of annealed cast steel at elevated temperatures

the X-ray at *M* refers to area 10 of the improved tee in the same way that 10 at *H* represents area 10 at *D*.

The X-ray at *M* is taken through the metal of a tee produced by the improved process. Its freedom from inclusions, as compared with *H*, is evident. The polished section *K*, the X-ray of this at *L*, and the etched surface *J* testify to the lack of gas, sand and dirt or other inclusions. The lower part of *H* has been touched up slightly, all else being reproduced direct. This series shows clearly the improvement resulting from an extensive study extending over a six-months period.

As a guide in the design and rating of fittings at elevated temperatures a series of physical tests at various temperatures was conducted in the physical testing section of the Ordnance Laboratory. The apparatus used in these tests consisted of a 100,000-lb. hydraulic horizontal testing machine, a resistance wound furnace, a recording pyrometer and a carefully calibrated platinum-iridium thermocouple. The results of this investigation are shown in Fig. 3. These bars were annealed and furnace cooled to a temperature well below the critical range.

The steel in the castings used for this investigation lies in the upper portion of the straight-low-carbon series. These steels are of the simplest possible nature. They lend themselves to ease of manipulation and, when properly handled in the furnace, the foundry and during heat treatment, show excellent physical properties.

Complication of the composition of the steel may cause it to show higher test-bar physical properties, but unless this is accompanied by assurance of integrity in the casting, no real gain will result.

Modernized Hotel Plant Shows Saving Over Purchased Power

By E. S. Glauch

The Belvedere Hotel, Baltimore, installed a power plant about 1904, and this was operated for a period of ten years, supplying all current and steam for heating as well as steam for heating water which was used in the hotel and in the laundry.

In 1914 a change was made to central-station current, the hotel continuing to operate the boiler plant for heating. Also, during this period a considerable quantity of gas was used in the laundry for heating water. In order to change over to central-station service, it was necessary to install a number of 220-volt motors in place of those operating at 110 volts.

After purchasing power for a period of nearly ten years, a thorough investigation was made in connection with modernizing the hotel plant in an effort to save money on power and heating bills. After making this examination, it was estimated by making some changes to the existing plant the management could save from $13,000 to $15,000 a year. It was necessary to rewind the generators for 250 volts in order that the equipment installed at the time of changing over to central-station current could be used.

The plant contained three slide-valve engines of 100, 150 and 200 kw. capacities, and in order to improve the efficiency, it was decided to convert the 150-kw. and the 200-kw. units to the unaflow type by the installation of dual clearance unaflow cylinders.

The cost of altering the engines, rewinding the generators, and installing balancing sets was approximately $20,000. During the last year that this plant was operated on purchased current, the cost of operation was as follows:

Current, 1,248,850 kw.-hr.	$24,238.96
Coal, 2,521.42 tons	14,563.58
Gas, 3,055,500 cu.ft.	1,943.00
Fixed charge	2,500.00
Total	$43,245.54

and the monthly costs were:

Month	Current	Coal	Gas	Fixed Charge	Total
January	$1,758.24	$2,043.56	$161.60	$208.33	$4,171.73
February	1,813.87	1,548.89	177.46	208.33	3,748.45
March	1,680.20	1,272.14	168.28	208.33	3,328.95
April	1,898.35	844.80	181.60	208.33	3,133.08
May	1,982.66	666.16	194.20	208.33	3,051.35
June	1,674.12	637.31	151.18	208.33	2,870.94
July	1,935.84	664.79	121.24	208.33	2,930.20
August	1,966.57	527.15	118.42	208.33	2,820.47
September	2,283.82	626.92	150.82	208.33	3,269.89
October	2,508.36	1,442.32	165.76	208.33	4,324.77
November	2,362.60	1,862.40	185.74	208.33	4,619.07
December	2,171.23	2,427.14	166.84	208.33	4,976.64
Total					$43,245.54

It did not require any additional help to operate the engine-generator units for they had continued to operate the boiler plant and had engineers on duty during the period of purchased power. The first month that all the current was manufactured with the modernized equipment the cost for current and heating was:

Coal, 399 tons	$2,394.00
Interest on cost of improvements	100.00
Depreciation and maintenance on improvements	166.66
Total	$2,660.66

and the cost of operation during January, 1925, was as follows:

Coal, 395 tons	$2,370.00
Interest on cost of improvements	100.00
Depreciation and maintenance on improvements	166.66
Total	$2,636.66

During these two months no gas was used in the laundry as the changes made in the boiler plant en-

abled them to use exhaust steam for heating and also exhaust and live steam for use in the laundry.

Comparing the figures for the first two months of operation against the same months of the preceding year shows a saving of $2,315.98 for December, 1924, and $1,535.07 for January, 1925. The savings for the balance of the year will easily make up the $13,000 which had been estimated would be saved by again operating their own plant, even though at the present time there has been a slight reduction in the cost of power and coal, compared with the year shown above.

The saving during the summer months will, of course, not be nearly so large as during the heating months, but it is estimated there will be a small saving even in the summer months when there is no heating required in the hotel, inasmuch as part of the exhaust steam will be used in the laundry.

Test of the Hesselman Solid-Injection Oil Engine

By Edvin Lundgren, M. E.

A detailed account of certain investigations and development work carried out in connection with the construction of a solid-injection oil engine designed by K. J. E. Hesselman, of Stockholm, Sweden, was published in *Power*, June 12, 1923. Since then another engine, based on the same principles, has been built by the Bofors Steel Works, Bofors, Sweden, and has proved highly successful.

The four-stroke-cycle engine has four cylinders, the liners of which are inserted in a common water jacket forming a rigid casting or block. The diameter of each cylinder is 15 in. and the piston stroke is 21½ in.,

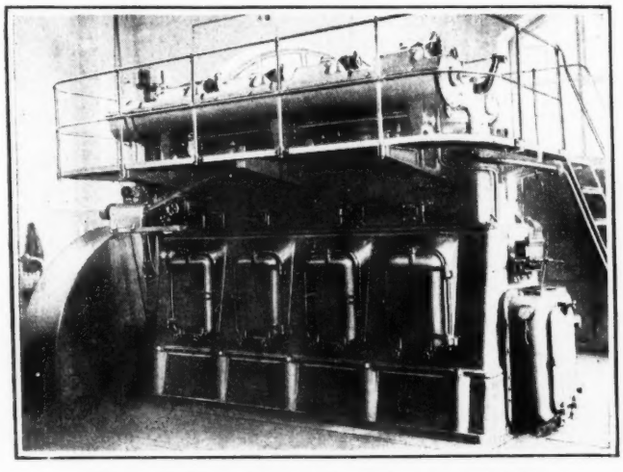


Fig. 1—Hesselman oil engine as built by Bofors Steel Works

making the rating of the engine 300 hp. at 220 r.p.m. with a mean effective pressure of 72 lb. square inch.

A very comprehensive test, carried out under the supervision of Prof. E. Hubendick, of the Royal Technical University of Stockholm, Sweden, gave the excellent results shown graphically in Fig. 2.

As will be noticed, the fuel consumption at the rated load is exceedingly low, amounting to only 0.375 lb. per brake horsepower-hour, based on the fuel having a lower calorific value of 18,000 B.t.u. per lb. This low fuel consumption is maintained over a wide range of load, even at 20 per cent overload. The maximum overload carried before the exhaust became visible, was 56 per cent, or 467 hp. A close inspection of the interior of the engine, particularly of the pistons, which are not water-cooled, did not reveal the least sign of overstraining or overheating. As apparently an overload of 20 per cent could be carried for any length of time, the

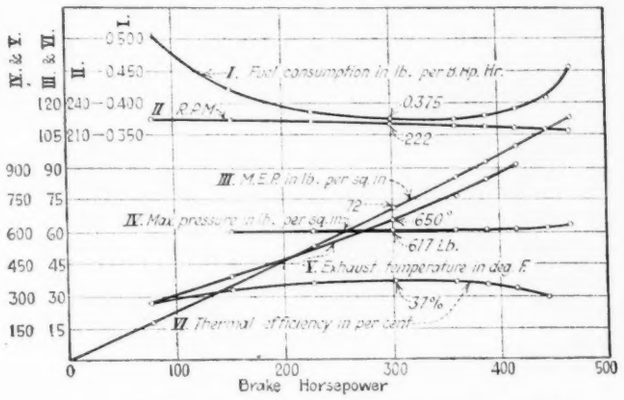


Fig. 2—Results of tests of Hesselman engine

power rating of the engine appears very moderate and indeed, a higher rating could be safely allowed.

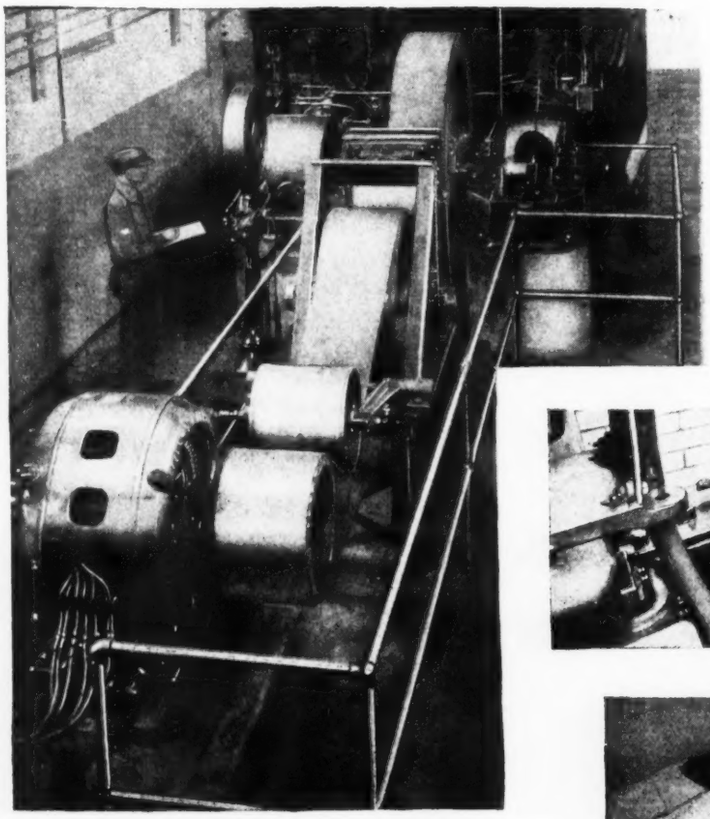
The combustion was perfect and regular, the exhaust being perfectly clear, and the indicator diagrams taken at definite loads showing a very uniform shape.

The fuel pump, which is driven from the vertical intermediate shaft by means of a cam with two lobes, is shown at the right in Fig. 1. The single pump, common for the four cylinders, receives two impulses during one revolution, which serve to feed the fuel to the two cylinders in which ignition has to occur during this time. The distributing delivery valves of the pump are actuated from the horizontal layshaft.

Bofors Works are going to build another engine of the same design, and several other Hesselman engines are being built under license by European manufacturers.

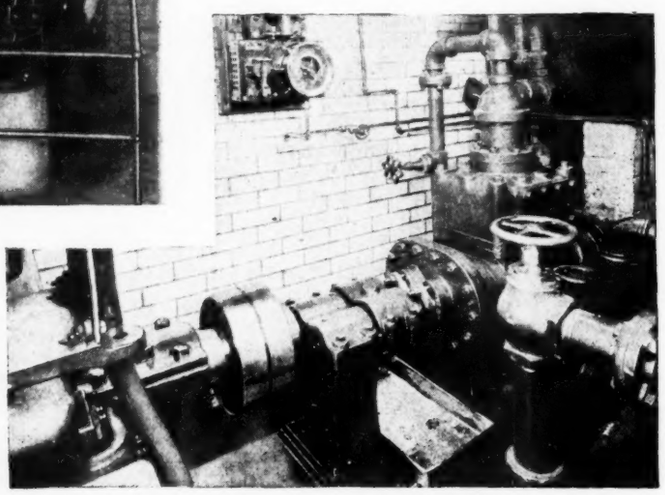
Metal that is clean is much more likely to make a good strong weld than when impurities are present. Scale, rust, grease, soot, and foreign matter will contaminate the weld, and such inclusions will necessarily weaken it or make it hard. Impurities may also make the metal porous and spongy owing to the liberation of gas. Pieces of foreign matter may prevent the molten metal from filling all parts of the weld and cause cavities or blowholes in the weld. Various methods of cleaning are in use; pickling for small parts, washing with gasoline or lye, boiling with lye, sandblasting, chiseling, scratch brushing, etc., the essential factor being to remove, as perfectly as possible, all impurities from the vicinity of the weld.

There is said to be renewed activity in bringing about the use of Massachusetts and Rhode Island coals. There are quite extensive deposits of a hard graphitic coal in these two states. With the growing scarcity and increased price of fuel from other sources and with the progress which has been made in furnace construction and coal-burning apparatus and processes, it is quite to be expected that these mines should eventually be worked to advantage.

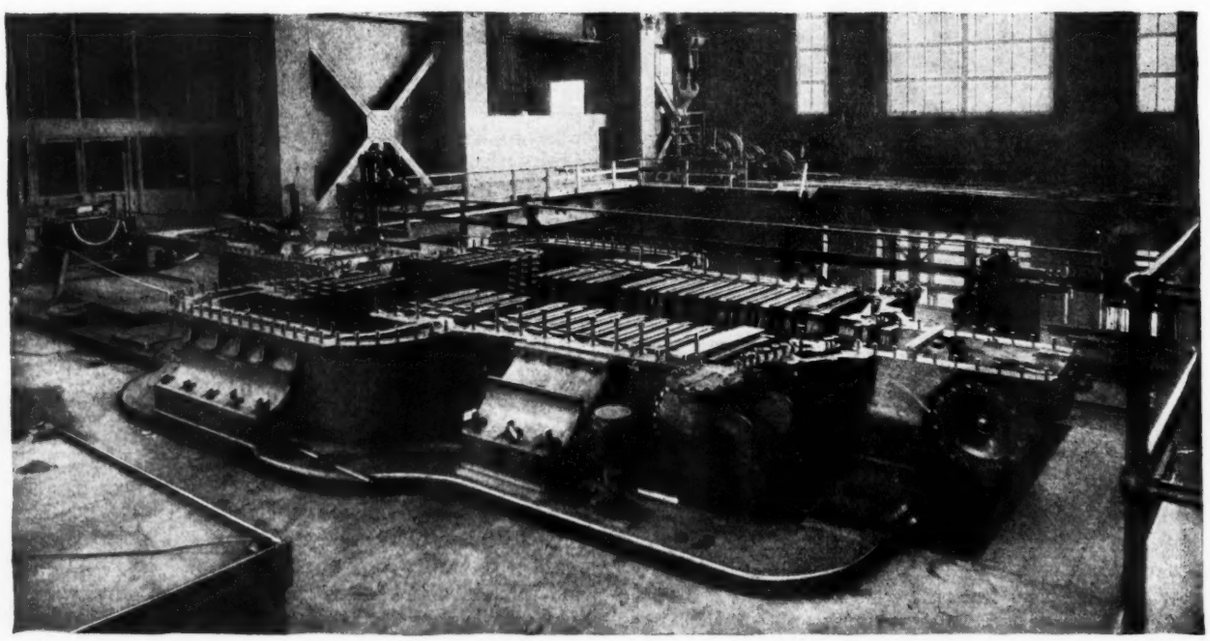


Above—Belt-tension dynamometer used in the shop of the York Manufacturing Co., York, Pa., to measure power consumption of ammonia compressors

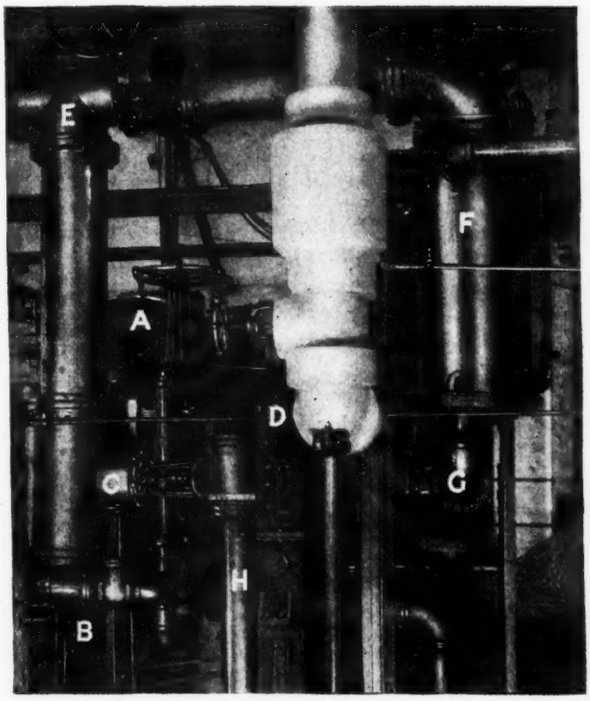
The screw pump shown below is still running in a downtown New York Office building after twenty-six years of continuous service without repairs



Above—These pieces of concrete recently stopped suction of a centrifugal pump at the New Orleans Water Works



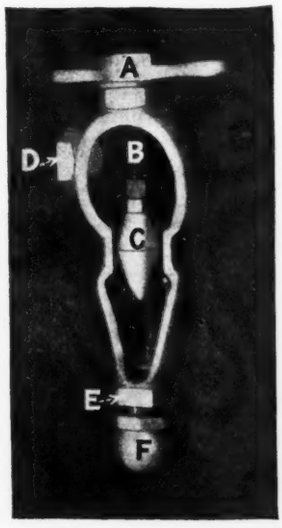
Scene in River Rouge Plant showing erection of 35,000-kw. turbine built by Henry Ford



Above—Heater arrangement at Merrimac Chemical Plant, Everett, Mass.

Main exhaust from turbine *A* passes through *B* and *C* to eductor-condenser *D*. Only part of steam is bypassed through *E*, heater *F* and *G* to condenser. This arrangement permits the use of a smaller heater with a corresponding saving in cost.

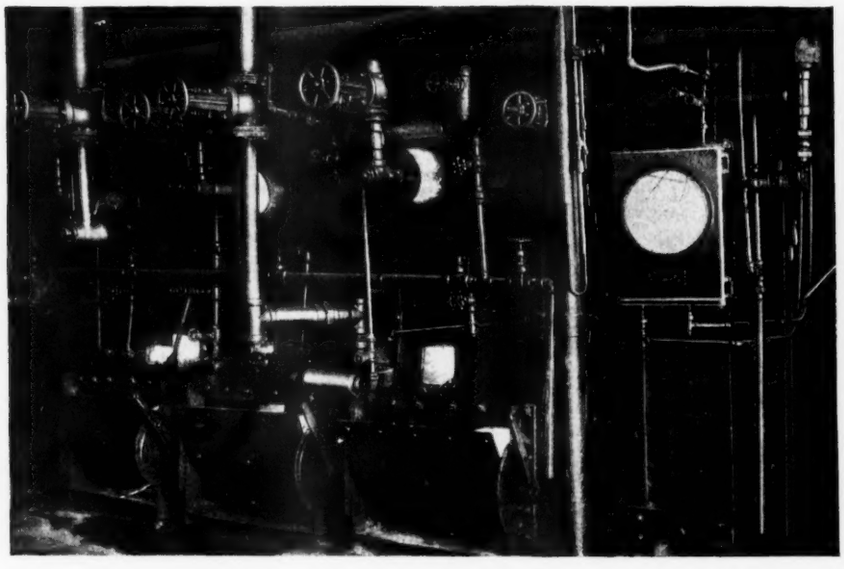
Below—Renewal of charts and ink is practically the only maintenance required by the thirty-five flow meters at the Corn Products Refining Co. plant, Argo, Illinois



Right—This shows one of the boilers in Mr. Walsh's plant equipped with his burner. The boiler is also gas fired (upper burners)

Left—George W. Walsh, mechanical superintendent in a large Massachusetts oil refinery, developed this burner to burn refinery waste in his plant

Oil entering at *A* under 200 lb. pressure issues in a thin disk through the adjustable slot between the cones *C*. Steam from *D* picks up the oil at *C* and sweeps it to *F*, from which it issues through one or more slits. The steam pressure required is 7 to 35 lb.



Coal Deposits and How They Were Formed

BY HERMAN H. WUESTNER

COAL consists of the same elements as plants, and often plant fibers, leaves, stems, nuts, seeds, etc., are found inclosed in it, and can also be found in the associated beds of rocks. The finding of trunks of trees and stumps in an upright position in coal seams, sometimes with their roots penetrating the underlying clay, leaves little doubt that coal has been formed from vegetation in association with water. The vegetable accumulations, which formed the coal, may have taken place in shallow ocean bays, beaches, in lakes, swamps or inland seas. The interior of the North American continent was covered with large bodies of shallow waters during the time coal was formed, and these bodies of water, slowly drying up, were likely the birthplace of numerous veins of coal.

BETWEEN 70 and 80 per cent of the production cost of power generation in the average steam plant is for fuel, which in a large percentage of the plants is coal. This fuel forms the world's greatest source of heat and power that can be utilized commercially. Without it modern civilization would be impossible, yet few engineers have ever given any thought as to how we became endowed with these great deposits of fuel which are estimated to last for thousands of years at the present rate of consumption. In this article the author tells an interesting story on the origin of coal and what influences were at work during the formative periods to affect its quality—Editor.

The geological time during which most of the coal was formed, is called the "carboniferous" or coal-bearing. While the carboniferous formation rightfully deserves its name, the "coal-bearing," we must bear in mind that not all coal was found in it. At the time coal was formed, there was a continuous change in the water level. The changes were often so slow that centuries may have passed while the ground would rise or sink only a few inches, or it would continue sinking, often to a depth of several hundred feet—sometimes, however, only a foot or less, as can be seen by the beds of rock formed between veins of coal.

While this rising and sinking was going on, the water in the ocean or bay would deposit the lime it held in solution or the mud it held suspended or the sand it carried along from ground-up rocks, to form limestone, shale or sandstone, upon the submerged vegetable matter, and thus, before the next rising began, would complete a distinct bed of coal. Rising and sinking of ground still goes on, but so slowly that it can hardly be observed in a lifetime.

The thickness of the carboniferous formation varies from a few hundred to about 10,000 ft., and from a few to almost 100 different veins of coal; and these again vary in thickness from a few inches to 50 ft. or more. In the United States the heaviest bed of coal is the "Mammoth" bed of anthracite in Pennsylvania, between 50 and 60 ft. thick; and from 200 to 300 ft. up another seam is found, the "Red Ash," 16 to 19 ft. thick, and the same distance above another 16-ft. bed.

In Pottsville, Pa., the formation is 3,351 ft. thick with 27 distinct seams of coal. The Pittsburgh vein is from 8 to 16 ft. thick, but 4 ft. of this coal cannot be used as a fuel. Illinois has 14 seams of coal, the thickest being 28 feet.

In Europe most of the coal deposits are called "basins," because coal extends down to great depths, but is confined to a small area. The Westphalia Basin is about 11 x 30 miles in extent, containing about 130 seams, while the basin at Saarbruck, 20 x 60 miles, has 240 seams.

Structure of the Coal Vein

The vein itself may be only a few inches or up to 50 ft. or more in thickness; it is not always uniform over a large area, it may narrow down. Then it is said, it pinches, or increases in thickness, or swells. The vein may split, leaving a seam of shale between. It may be cut vertically by a clay vein, which in turn may have a thickness from a few inches to 20 ft. or more. These clay veins were apparently formed by erosion during or after the coal seam, or they may be filled in fissures, formed by folding of the strata. There may also be "faulting" in the stratas; the coal may thus become "lost" and may be found again at a higher or lower level.

Plants that formed the different kinds of coal were not all of the same kind, and they differ during the several geological periods during which they grew. It is known that different kinds of plants at the present day contain different chemical substances, which they absorbed from the soil, and which were necessary to build up their bodies. Some need lime, some potash, and some of our grasses contain so much silica that the edges cut like a knife. If it is considered that in burning vegetation, similar to that of which coal consists, the incombustible substance (called ash) amounts to only about 2 per cent, then the conclusion must be arrived at that the remainder of the impurities above this amount got into coal from a different source. There may have been floods occasionally, which carried fine mud or other substances over the vegetable coal-forming matter, and in some beds of coal the small seams of so-called "slate" are in reality nothing but dried mud.

In the Pittsburgh vein there is found about one foot of clay between the upper and the lower half of the bed, indicating that a short sinking took place. The lower part is an excellent coal, low in sulphur, but the upper is so high in sulphur that it cannot be used. Numerous small veinlets of iron sulphide or marcasite are penetrating it. The sulphur may have come chiefly

from the plants, but it is not understood how such a great change took place during a short period.

The lower part of this vein, where it rests upon a solid limestone, is not used, as it is badly decomposed. It appears that the limestone did not afford any drainage, and the coal lay steeped in water usually charged with acids and other impurities, probably for centuries, and consequently rotted the lower part, about a foot or more. A small vein of shale or "slate" as it is commonly called by miners, about ¼ to ½ in. thick, is found in the above-named seam of coal (it is called by miners the bearing in slate), which is so persistent that it can be found anywhere in this seam, which covers an area of about 14,000 square miles. As this slate is nothing but dried mud, this should indicate that when this bed was formed the atmosphere must have been very calm, and also the sinking of the ground very uniform to produce such a thin sediment over such a large area, practically undisturbed. A sinking undoubtedly took place; a flood could hardly produce such a uniform sediment. It is known that a long time, probably thousands of years, may have passed from the time the first coal was formed, up to the forming of the last vein; therefore, the earlier coals are much older than the later, and consequently, they went through processes that the later were not subjected to. In the earlier, the volatile matter to some extent, was driven off by heat and pressure. They are often found much deeper, covered and protected by heavy overlying beds, while the later are usually near the surface. As a rule, the older coals are the best, the youngest the poorest; therefore, the quality of a coal, approximately speaking, decreases in the United States from east to west, although it must be remembered that some excellent coal, even anthracite, in small patches is found in the Rocky Mountains near the Pacific Coast.

Peat is an accumulation of partly decomposed vegetable matter in swampy places. The moss-like plant begins to grow at the edge of a pond or small lake; it soon spreads over the whole surface, and while growing at the surface, it is dying off below. This dead moss drops to the bottom, and in this manner, while filling the pond from below with dead moss and spreading over the surface, it soon takes possession of the whole pond, and thus often forms deposits over large areas. As the deposit increases in bulk and pressure, the moss at the bottom becomes almost black in color and often closely approaches the composition of brown coal, but from this it can be distinguished by its readily visible plant fibers, only partly altered. While peat and coal may have formed in a similar way, the vegetation forming peat was steeped in water, and a free admission of air was excluded, preventing decay; while some of the coal forming material after having been steeped, may have been covered with earthy matter which excluded the air entirely, after the vegetable matter had undergone certain changes before burial.

It has been estimated that five feet of vegetable matter will give one foot of coal; this, of course, depends on whether the vegetable matter was changed to lignite, bituminous or the anthracite stage; and again whether it was formed with air excluded or imperfectly excluded, pressure from heavy overlying beds, or no pressure. The process was similar to that of making charcoal; that is, subjecting the wood to a half-smothered combustion, by excluding the air, driving off all or a certain amount of volatile matter, leaving the coal higher in carbon. The chemical changes that take place, in vegetable matter when formed into coal, can be seen in the following analysis, which is from the United States Geological Survey:

	Carbon	Volatile Matter
Wood	49	..
Peat, brown	30	40
Peat, black	34	39
Lignite—Calif.	36	38
Lignite	48	36
Brown coal	54	30
Bituminous coal	62	26
Pocahontas	74	18
Anthracite	93	5
Graphite-anthracite	97	2
Graphite	99	0

Ash not considered.
Wood contains about 49 per cent carbon, but a great deal of this is lost during the forming of peat or lignite; the large amount of impurities and moisture also reduces the percentage of carbon in those hydrocarbons.

DURING the coal formative periods forests and jungles consisting of tropical plants covered boundless plains and marshes, which had newly emerged from the waters, forming a fertile soil; and as the climate of the earth, at that time, could not have been colder than that of the modern temperate zone, the atmosphere warm, evaporation and precipitation excessive, there was nothing wanting for the most luxurious growth of vegetation. The plants were those generally found in a tropical climate, of a giant nature, and nearly all are extinct. It also seems likely that there was more carbonic gas in the atmosphere at the time coal was formed than now, which also favored the growth of vegetation.

Some years ago I had the opportunity to observe the forming of charcoal from vegetable matter in a comparatively short time. A large pile of cleanings from grain, such as wheat, oats, chaff, straw, corn husks and silk, etc., had accumulated during a period of five or six years, until this pile had reached a diameter of about 50 ft. and a considerable height, and as it was exposed to the weather, it would receive a few inches to a foot or two of cleanings between rains or snows. When this material was removed, it was found that the outer five or six feet was very wet and not much changed. The next few feet was very hot and of a blackish-brown color. The heat increased toward the center; a blue smoke would rise when some of the material would cave in, and the material was completely turned into charcoal, but still it retained its original structure. A core about six or eight feet in diameter in the center of the stack was cool and was a black powder, pure carbon with a little ash.

This instance is mentioned, as it may throw some light on the forming of coal, and shows that where conditions were favorable coal may have formed in much less time than is generally supposed.

Lignites or Brown Coals

The lignites, or brown coals, form the link between peat and bituminous coal. They graduate into each other, so that if it were not for the younger age of the former in some cases, they could not be told apart. They often retain the structure of the original wood, and some even contain nuts, cones, leaves and other products of the forest, still well preserved. They vary in color from light brown to pitch black. They also often contain the resin or gum from trees, which resembles amber, and this substance has been a hin-

drance in the making of brown coal into umber paint. In grinding the coal, the resin flattens and cannot be ground fine enough to pass through a very fine mesh, necessary to produce a paint free from grit. The resin from one ton of coal from Arkansas gives about ten gallons of varnish oil. Lignites are either fibrous, earthy or conchoidal, the last-named joining on bituminous coal. Jet, which is used in jewelry, is a variety of lignite. Often logs that have been inclosed in beds of peat are turned completely into jet.

Bituminous coal is the going over from pitchy lignite to anthracite and graphite.

Forming of Anthracite

While some of the anthracite veins may have formed in the same way as bituminous coal, the geological structure of nearly all anthracite deposits is such as to indicate that mountain building forces, heat and pressure converted the coal to the anthracite stage. The pressure from the interior raised the surface, tilted the rocks, creating joints and fissures in the stratas, and thus forming openings, so that the heat from below could rise, percolate through the coal deposits and assist in carrying off the volatile matter. Some faults or slips in the ground have been observed 130 miles long. One bed of coal produces bituminous coal in Ohio and lies horizontal and undisturbed; through part of Pennsylvania it is mined as anthracite and is greatly tilted, while in Rhode Island it is converted into graphite and graphitic anthracite and is so broken up that portions of it cannot be worked at all. This bed, being of the same geological age, shows plainly that where disturbances were the greatest, the most volatile matter was driven off. It can also be seen that for the aforementioned reasons, anthracite is much more difficult to mine than lignite or bituminous coal.

As a general rule the carbon content of coal decreases from east to west in the United States. In Rhode Island and New Jersey graphite and graphitic anthracite is found; in Pennsylvania, anthracite; in West Virginia, the Pocahontas, and New River coal, which ranks between bituminous and anthracite; in the Middle States, bituminous; through the Western States, lignites occur with the exception of patches of all kinds up to the graphite in the Rocky Mountains, due to mountain-building forces, while in Oregon, California and Nevada we find the poorest and also the youngest of the coals.

Volatile Matter

Next to carbon the gases hydrogen and oxygen are the other two necessary ingredients in coal. They are usually called "volatile combustible matter," and they give light and flame, the flame being necessary in a coal used for steam purposes and the light for gas production. The volatile matter should range from 20 to 40 per cent, while above 40 per cent it detracts considerably from the value of a coal. A great deal depends, of course, on what proportions these gases are present.

If one pound of hydrogen could find eight pounds of oxygen with which to combine, it would form nine pounds of water and no benefit would result. Oxygen alone would support combustion, but this could be taken in from the atmosphere, and its weight may be replaced by carbon in coal. The hydrogen that can find no oxygen with which to combine is called the "disposable hydrogen," and it is the most necessary ingredient in a coal used for gas production. In some cannel coals, the disposable hydrogen amounts to as much as 7 per cent. One pound of hydrogen will produce 60,000 B.t.u. or about four times that of carbon. In the average bituminous coal the amount of hydrogen runs between 2 and 4 per cent for every 10 per cent of volatile combustible matter.

Ashes of Most Coals Will Clinker

The ashes in a coal are rarely less than 5 per cent and often as high as 20 per cent or more. The ashes from most coals will remain loose under ordinary conditions, while others will form a clinker, but when sufficient heat is produced in a furnace, the ashes of most coals will clinker. This depends on the chemical composition of the ashes. Ash, high in silica and iron, will clinker from 1,150 deg. C., while an ash high in alumina and lime will remain loose up to 1,250 deg. C. or more. Contrary to general belief, that sulphur, if present in large quantities will form a bad clinker, tests have proved that a coal with 5 per cent sulphur can easily be burned without forming a clinker, provided no other clinker-forming elements are present. As the amount of ash in wood is only about 2 per cent, any above this amount must be charged up to wind and wave action at the time the coal was formed. This mixing of earthy and vegetable matter in some beds of coal sometimes went on to such an extent that the bed is so impure that it cannot be used as a fuel.

If a bed of coal has not been impregnated with fine mud throughout and only spots are rendered impure so that we can find dull spots or streaks running through it several inches thick, or large lumps are found, the name of bone coal or nigger head is applied to this impure coal. Bone coal is far heavier than ordinary coal, it has little or no luster and an iron gray rather than black. When put in a furnace, the carbonaceous matter burns out and the whole mass burns white, but retains its original structure, therefore forming no clinker.

Effects of Sulphur in Coal

Sulphur is present in coal in three different forms. Of these three kinds the minerals, pyrite and marcasite, which have a brass yellow to whitish color and which contain 53 per cent of sulphur and 47 per cent iron, are the most detrimental and one of the worst ingredients in a coal. While not detracting so much from the fuel value, it is more feared on account of the corrosive effects it has on iron surfaces, especially in the presence of moisture with which it forms sulphurous acids. More or less of these acids impart themselves to the soot which covers iron surfaces and corrodes them. This iron sulphite occurs in coal in such small particles that it cannot be observed with the naked eye. Often, however, it is found in streaks several inches thick or in lumps in size up to a foot or more in diameter. If present in large amounts in a fuel, it takes up much heat from the furnace in its fusion. Coal with much iron sulphide cannot resist weathering.

Water or moisture, as it is generally called, is of no benefit and acts detrimentally upon a fuel. Considerable heat is used up in driving it off, and it replaces its weight in combustible matter and also causes the coal to break up as it dries out.

Anthracite is most desirable where a great heat and not necessarily any flame is desired, but as its production is limited and the price often high, a caking or coking coal is frequently converted into coke, which is also high in carbon and generally can replace anthracite.

Preventing Breakdowns of Electrical Equipment

By C. R. CHACE
Engineering and Inspection Division, The Travelers Insurance Company, Hartford, Connecticut

A LARGE percentage of the failures in electrical equipment are preventable by proper inspection and maintenance methods, and this article shows the way.

PRACTICALLY all electrical-apparatus failures may be roughly divided into four classes: First, those that are classified as purely mechanical failures, which form the largest class and can be prevented in almost every case by the operating engineer. Second, those that can be classed as electrical failures, which are much less numerous and can be controlled

Fig. 1—What remained of a large motor-generator set, consisting of two direct-current generators driven by an induction motor, after the generators had been motorized and run away

to some extent by correct installation, proper protective equipment and good maintenance of that equipment. Third, there are the many failures due to deterioration of insulation through age, unusual atmospheric conditions, severe service, etc. These may be prevented in a large measure by regular testing of machines followed by correct treatment of insulation when found weakened or defective. Lastly there is the smallest classification of failures, the unknown, sometimes referred to as bad luck, natural causes, etc., for which apparently no cause can be found but for which preventive measures can be taken. In the writer's experience more than 50 per cent of the breakdowns of electrical machinery fall in the first class.

The most common and frequent cause of electrical machinery failures, mechanical in nature, will be considered first. Dirt is the veteran enemy of electrical apparatus. How many steam-plant engineers of the old school, who consider a spot of dirt or rust on a connecting rod or crank of their engines a public disgrace, will install a motor in some out-of-the-way corner of the plant, connect it to its load and to the line and then proceed to forget its existence until a breakdown occurs. Probably the only maintenance that this motor receives is an occasional bath of oil aimed in the general direction of the bearings by some careless employee not of the engine-room staff. Is it strange, then, that this neglected machine finally refuses to bear up under its abuse any longer and gives up the struggle? Electrical apparatus, like all other machinery, must be kept clean.

The first step in caring for motors and generators is to keep dirt out of the windings. In winding a machine, small spaces or ducts are left between the coils to permit of free air circulation in order to dissipate the heat generated in the windings and keep the temperature of coils and their insulation within safe limits. Air ducts are also provided in the armature core to assist in dissipating the heat generated in the machine.

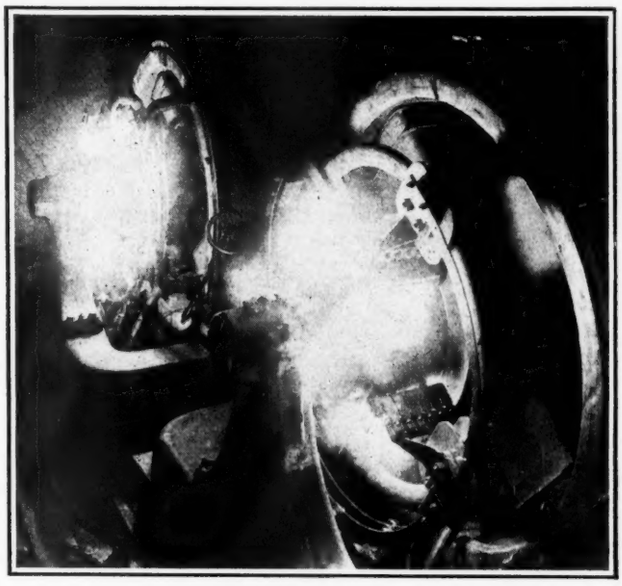


Fig. 2—Flashover on two rotary converters resulting from a 1,200-volt short-circuit

When the unit is running, air currents are set up through these spaces by the revolving rotor and if the machine is not of the totally inclosed type, any dust or dirt in the atmosphere is drawn into these spaces and deposited on the coils and core. In a dusty atmosphere these ventilating spaces are soon clogged, the machine runs hot, rapid deterioration of the insulation is set up and the unit burns out. The best way to prevent this trouble is by frequent blowing out of the machines preferably with air under a fairly high pressure. The pressure to be used must be determined by the character of dust to be removed. With a light dust, twenty to thirty pounds is usually sufficient, but with a heavy dust which clings to the insu-

lation fifty to sixty pounds may be required. The frequency of cleaning depends upon the amount of dust around the machine. In the writer's opinion machines should be blown out at least once every two weeks. In plants where considerable dust is present, once or even twice a week should be the rule; while in plants where

Fig. 3—Core of large alternator after an insulation failure to ground in one coil burned out the winding and badly burned the core at A

the dust hazard is severe, the machines should be cleaned and blown out daily. After blowing out the unit should have all exposed parts thoroughly cleaned with waste or wipers, care being taken to remove all surplus oil, grease and other foreign matter from on or around the machines. This schedule of cleaning does not apply of course to large generators which are usually supplied with washed air or ventilated by the closed-circuit system.

A particularly serious dust hazard with which the writer had to deal some time ago was that of graphite dust in a lithographing plant. This dust is of an oily, clinging nature which makes it difficult to remove from motor windings. It is also a conducting material and has the property of readily penetrating the pores of insulation, turning it into a conductor and soon causing a ground or short-circuit with its accompanying burn-out. There are two ways of dealing with a condition of this kind. One is to impregnate the windings with a special insulating compound prepared by the manufacturers and designed to resist the attack of graphite, and the other is to use a totally inclosed dust-tight motor, or a dust-tight metal housing ventilated to the outside air.

Next to the dust hazard in importance comes the lubrication problem. The number of machine failures caused by the lack of lubrication is about equal to the number caused by an excess. A large proportion of electrical units are of the ring-oiled type. Bearing trouble is frequently caused by a lack of oil in the bearing reservoirs to be picked up by the rings, installing and starting new motors without oil, loose drain plugs in the bearing reservoirs allowing oil to leak out, rings which are stalled by dirt in the oil, use of too heavy a grade of oil, small mechanical obstructions and the like. Bearing trouble is also caused by obstructed oil passages or grooves, excessive belt pull, misalignment of the machine on its base rails. Overheated bearings have been known to occur from a ground causing current to pass through the bearing and from shaft currents due to improper design. Preventive measures for any of the foregoing failures are obvious to any operating engineer.

Oil has its place in a motor, but that place is in the bearings and not on the windings. Many mechanics, so called, when oiling a machine pour oil into the bearings until they overflow and the oil runs out around the shaft through the opening in the end of the bearing housing. The oil creeps in along the shaft and is thrown about on the windings by the revolving rotor. The writer has often found anywhere from a quart to a gallon of oil in the lower part of the motor frame, forming a pool in which the lower part of the windings was completely submerged. It is an accepted fact that oil or grease causes the insulation of machine windings to deteriorate rapidly and frequently results in a breakdown.

Extreme care should be used to see that oil is not allowed to become deposited on the windings, but if any does get on, it should be carefully and promptly wiped off. If the insulation by any chance should become oil soaked, the motor should be removed from service and dried out in a baking oven at approximately 200 deg. F. for a period of about twenty-four hours, after which all exposed parts of the windings should

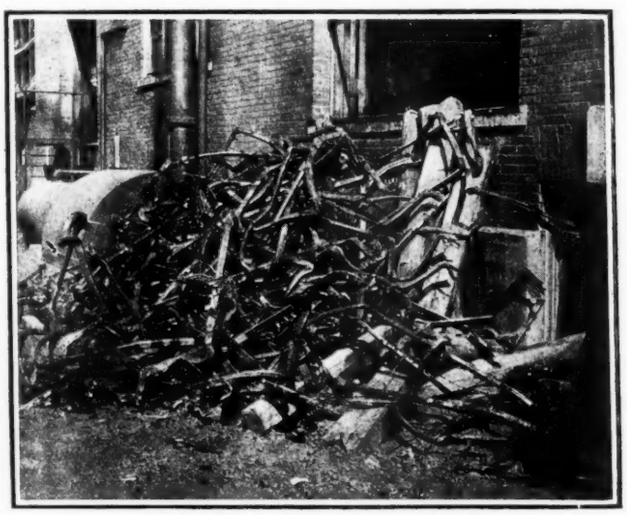


Fig. 4—Winding taken from the stator core shown in Fig. 3

be given a coat of air-drying shellac or insulating varnish which should be allowed to dry thoroughly before the machine is returned to service. It is a mistake to dip motors in gasoline to remove oil from the windings, since gasoline will often loosen the insulation on the coils.

Small air gap between rotor and stator of a machine is a frequent source of motor breakdowns. The

gradual wear of bearings decreases the air gap or clearance usually at the bottom and sometimes at the side toward the belt pull until the rotor rubs on the stator. This rubbing loosens the wedges which hold the coils in place, causing the coils to come in contact with revolving rotor. The insulation becomes rubbed off in this way and a breakdown occurs. This trouble can be prevented by frequent and regular checking of air gap on all machines. A set of feeler gages to be used for this purpose can be purchased for a small sum from motor manufacturers.

Many of the troubles experienced with direct-current machines can be traced to the commutator. It is a mistake frequently made by operating engineers to use oil in lubricating the commutator. In general commutators require no lubricant as sufficient lubrication is usually provided by the brushes. Oil, when used, becomes mixed with carbon particles and dust, forming a paste which, when baked by the heat of the commutator, forms a conductor between bars and leads or short-circuits and flashovers. If a commutator becomes annoying by the squealing and noise of the brushes, the very slightest application of vaseline on a cloth will cure the trouble.

It is advisable on most machines running at 750 r.p.m. and higher to undercut the mica somewhat. On slow-speed machines this is not advisable, however.

Brushes and Brush-Holders

Loose brush leads, broken springs, broken insulation on brush studs, improper brush adjustment, worn out brushes, improper grade of brushes and defective brush-holders all give rise to trouble and when discovered should be repaired or replaced immediately. Excessive brush tension causes overheating of the commutator, grooving, etc. The correct brush tension may be determined by using a spring balance and should be between 2 and 2½ lb. per square inch.

When a commutator has become badly pitted or grooved, it should be dressed by removing the armature and placing it in a lathe or in large machines by using a special form of tool rest and turning the armature after having removed the brushes. A light cut should be taken over the commutator surface to true and smooth it up, after which it may be polished by using a fine grade of sandpaper. Grinding is also coming into general use as a means of truing up commutators.

The secret of success in maintaining motors and generators, or in fact any electrical equipment, is the regularity in care and adjustment and periodic inspection. It is proper that all electrical machinery receive at least a daily inspection or visual examination for mechanical and electrical defects. In addition to this, oil should be changed, air gaps measured and the units cleaned at regular intervals. It is also advisable wherever practicable to maintain a log or record of the condition of all equipment as found at the time of inspection. This inspection service by plant employees can well be augmented by regular inspections made by some disinterested party such as a manufacturer's service engineer, an insurance company's inspector or electrical-maintenance company's representative.

Starting and control equipment, as well as all switchboard equipment, should come in for routine inspection, regular cleaning and blowing out, renewing of contacts, etc., since it, too, is frequently subject to failure from ordinary mechanical sources.

In maintaining transformers there are two things to watch—the temperature and the dielectric strength of the oil. The temperature of the oil should be determined on large units at regular intervals and under normal operating conditions should not exceed 75 deg. C. Samples of oil should be taken from the lower part of the tank or casing at regular intervals and subjected to a high-voltage test for dielectric strength. The dielectric strength of new oil ranges from 22,000 to 25,000 volts per 100 mils. Should the dielectric strength become less than 75 per cent of this amount, the oil should be removed and filtered and dried or replaced. Any serious sludging of the oil should be regarded as a danger signal and steps taken to remedy the trouble at once.

Use of Protective Devices

So-called electrical troubles may be prevented to a large extent by correct installation and the use of proper protective devices. By electrical troubles are meant overloading, single-phasing operation of polyphase motors, low voltage or high voltage, line disturbances such as surges and high frequency oscillations, lightning disturbances, etc. The use of overload, reverse-current and reverse-power, differential, reverse-phase and phase-failure relays, fuses, lightning or surge arrestors, choke coils, current-limiting reactors, low-voltage releases, etc., will minimize these difficulties. It must be borne in mind, however, that the use of the most elaborate system of protective devices is of no avail unless these devices are correctly installed and properly maintained so they will function when the emergency arises.

The frequent examination of relays to see that they are properly set and of fuses to see that they are of proper size and that they have not been blown and refilled with over-sized fuse wire or a piece of wire, as well as the regular testing of low-voltage releases and all relays to see that they operate, is a very necessary part of plant maintenance. Lightning arrestors that require charging should be charged daily. Arrestor gaps should be measured regularly to see that they have not changed, and ground connections should be examined frequently. At least once a year and preferably twice, the arrestors should be thoroughly overhauled and the ground resistance measured.

Insulation Deterioration

Deterioration of insulation through age, wear and tear, etc., is a gradual process that begins as soon as a machine leaves the factory. It is hastened or retarded by the conditions under which the unit is required to operate and the service imposed upon it. The failure of the insulation is inevitable, but it can be postponed or in some cases predicted by careful watching and regular testing.

A great deal can be learned of the condition of insulation from time to time by measuring the insulation resistance at regular intervals and by frequent visual inspection. Such conditions as oil-soaked, dirty, cracked, charred, burned, broken, hardened and loose insulation can be detected by a careful visual examination. The measure of the resistance of insulation to the passage of current is a good indicator of its general condition, particularly if the measurements are made at regular intervals of once a month or at least once in three months and the results charted. Small-voltage machines of 600 volts and under should have an insula-

tion resistance of at least one megohm. The minimum resistance in megohms for units of large capacity may be determined by the formula,

$$\frac{\textit{Rated voltage}}{\textit{Rated kva.} + 1{,}000}$$

If the insulation resistance is found to be materially less than the values indicated in the foregoing, it shows one of two things. There is a partial ground in a coil, lead, brush-holder or at some other point in the machine which permits a current leakage, or the strength of the insulation has become weakened in all parts of the machine. In the former case the remedy is obvious, but in the latter case the remedy depends on the extent of the weakness, the kind of insulation and the cause of the trouble.

If the weakness is due to moisture, the remedy is to dry the unit out thoroughly at a temperature of about 200 deg. F. until the resistance measurements indicate that the strength of the insulation has been restored. If the trouble is due to dirt, a thorough cleaning and blowing out of the winding usually corrects it. Insulation that is oil soaked or greasy must first have all oil or grease carefully wiped off the coils, care being taken in wiping it off not to injure the insulation mechanically. The machine should then be baked at a temperature of about 200 deg. F. for twenty-four hours or longer if necessary, until the oil has been dried out. After baking, the windings should receive a varnish treatment. If the insulation has not become seriously deteriorated, it should be given a coat of shellac or air-drying insulating varnish by dipping, brushing or spraying. This will exclude air and moisture and preserve the insulation. If the insulation has become badly deteriorated, loosened, cracked or charred, the unit, if possible, should be dipped in a good baking varnish, taking care to see that the varnish penetrates all parts of the windings, after which the machine should be baked until the varnish has become set and hard. If these treatments fail to restore the insulation resistance to a sufficiently high value, rewinding is the proper remedy.

Mica insulation cannot of course be treated as can fibrous insulation. Trouble from defective mica can usually be cured only by reinsulating.

It will be found that many of the accidents that appear to be unassignable to any cause and that "just happen," will be prevented by proper maintenance of the equipment, since these are not usually mere happenings, but can be traced in almost every case to something neglected.

An Obstructed Venturi Meter

By ROBERT W. ANGUS
Professor of Mechanical Engineering, University of Toronto

A VERY unusual case in connection with a venturi meter recently came to the writer's attention which may be helpful to engineers using the device. As is well known, the measuring tube consists of a pipe in which are two cones and a short cylindrical piece of pipe, which is much smaller than the main in which the device is placed.

The smoothness of the tube and the absence of corners and projections of any kind have made it particularly free from interference from floating sticks and other materials that may happen to pass through the meter, and some large pieces of material have passed through the tubes without causing trouble. The meter under consideration proved an exception to this rule,

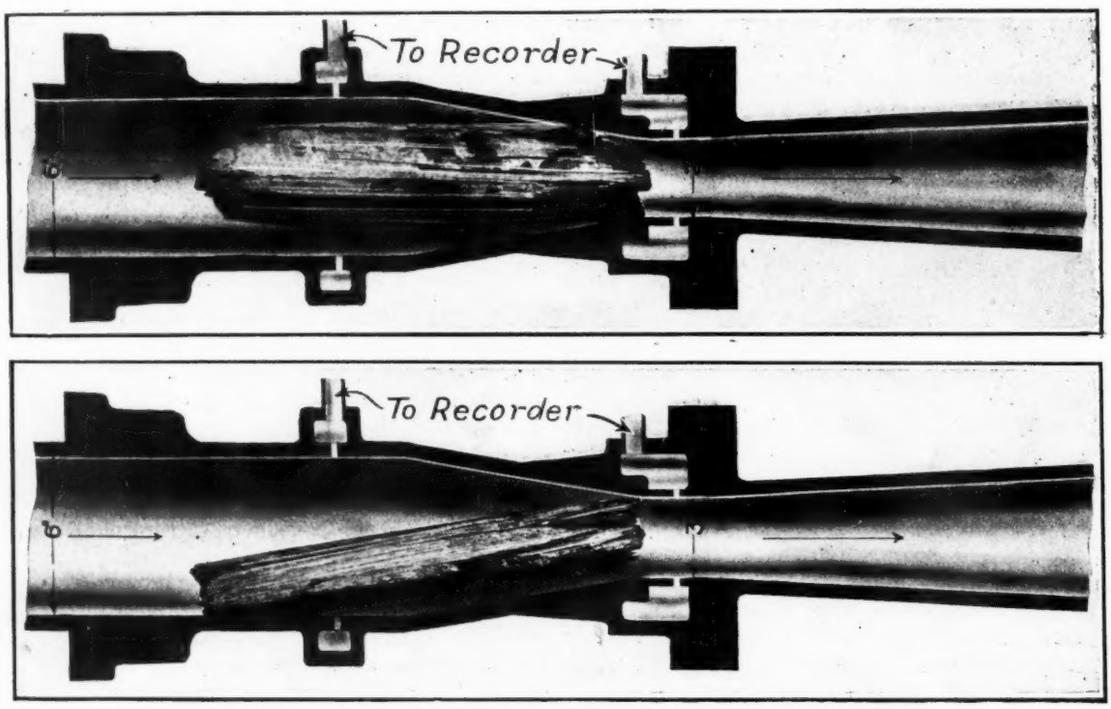


Fig. 1—Section of venturi meter with stick in place (plan view above)

however, and the photographs shown herewith give a side elevation and plan of a large piece of wood that lodged in the upstream cone. The proportionate part of the area taken up by this piece of wood may be judged from Fig. 1.

This meter was a 6-in. tube with 3-in. throat and was used by the town of Mimico, Ontario, for measuring the amount of the municipal supply furnished them by the town of New Toronto, Ontario. For some time the meter worked well, but suddenly the demand for water by Mimico apparently increased so much as to tax the full capacity of the meter and of course caused some anxiety on the part of Mimico as to the size of their water account.

When this condition of affairs had continued for some time, a new tube was decided upon, which was finally purchased, and it was during the installation of this tube that the trouble was discovered.

Water Bill Corrected by Calibrating Venturi Meter with Obstruction in Place

The next question was the correction to be made in the water bills, and on being consulted by T. M. Staunton, chairman of the Public Utilities Commission of New Toronto, the writer advised calibrating the meter with the stick in place and in this way getting a correction curve for the recorded volume. The meter was accordingly set up in the hydraulic laboratory of the University of Toronto, and a mercury gage was used to determine the differential reading.

Water was then pumped through the tube at capacities of from 50 Imperial gallons per minute up to 550 Imperial gallons per minute, the water being passed over a V-notch weir for measurement. Measuring the discharge with and without the tube in place, the correction curve shown in Fig. 2 was drawn, from which it is easy to see the actual discharge corresponding to a given reading on the recorder; that is, to a given differential reading. In order to see whether the position of the wood affected the result, a number of tests were made. In one of these the wood was drawn firmly into place by a wire, but the readings were the same as when the wood was allowed to find its own place, showing that the results were dependable for determining the flow during the period when the meter was obstructed.

The curve enabled a very speedy and amicable adjustment of the account to be made when it was used in connection with the records kept by the municipality, the time at which the trouble began being fairly definitely shown on the records. The experimental work described herein was done by J. E. MacAllaster, B.A. Sc.

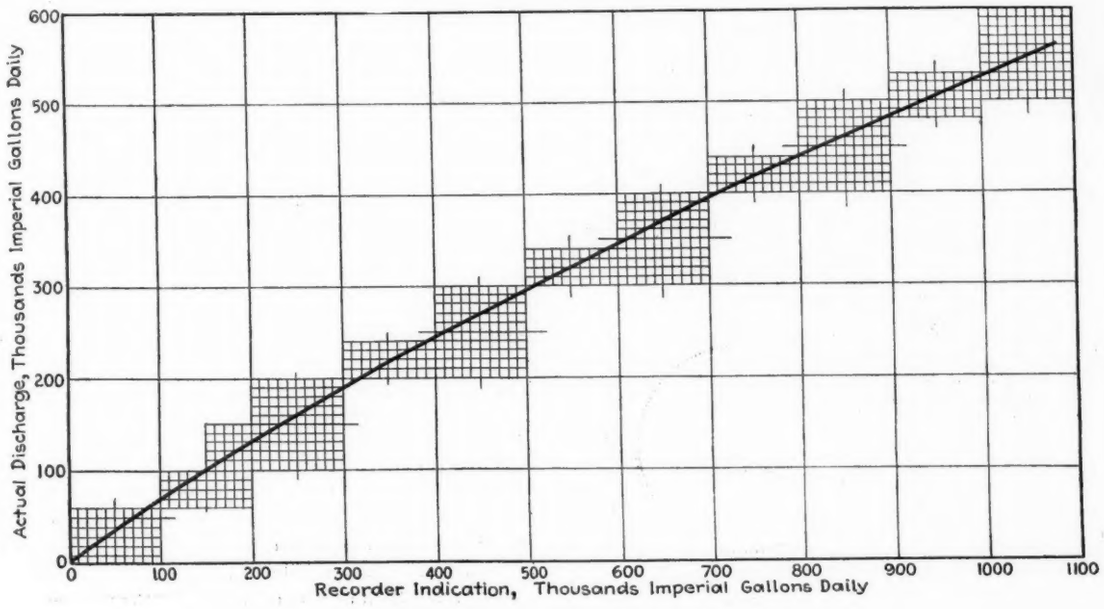


Fig. 2—Calibration curve made with stick in place

Efficiency of Domestic Heating Boilers

On account of domestic heating boilers being small in capacity as compared with those for power plants, and ordinarily purchased on a basis of price without regard to efficiency, it would seem reasonable to expect much wastefulness of operation. Tests, however, made some years ago on a number of boilers showed that at loads from 50 to 100 per cent rating, with semi-skilled attention, the average thermal efficiency proved to be around 60 per cent, while at low ratings this was well below 50 per cent. These tests included lignites, bituminous coals, anthracites and cokes as fuel. Anthracite and coke gave efficiencies roughly 15 per cent higher than the other fuels.

During the last year a series of tests of domestic boilers, made for determining the amount of heat absorbed by the different sections of such a boiler, as well as matters of air supply, indicated that over-all efficiencies, including combustible in the ash, ranged from 55 to 67 per cent with anthracite, from 40 to 53 per cent with bituminous and from 63 to 71 per cent with coke. The normal heating surface was here utilized. In order to simulate practical operating conditions, as little attention as possible was given to the fuel bed. The average amount of attention, such as changing the draft from two to four times in an eight-hour period, was followed. These tests were conducted jointly by the American Society of Heating and Ventilating Engineers, and the United States Bureau of Mines.

Central-Station Pipe-Line Refrigeration*

Method of Insulating Pipe Lines—Detection and Isolation of Leaks—Electrically Controlled Gate Valves—Charges for Service

By A. W. OAKLEY†

THERE are two general systems of pipe-line refrigeration in use in the United States—those circulating ammonia and those circulating brine-solutions as refrigerating mediums. Of the two, the latter seems to be the preferred method. A brine system in the downtown section of New York City, serving the dairy products, poultry and produce trade,

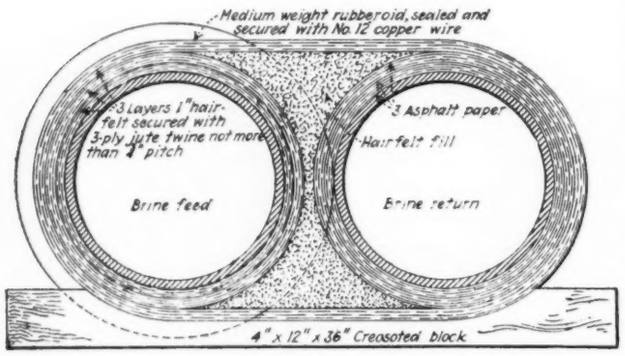

Medium weight rubberoid, sealed and secured with No. 12 copper wire
3 Layers 1" hair-felt secured with 3-ply jute twine not more than 4" pitch
3 Asphalt paper
Hair felt fill
Brine feed
Brine return
4" x 12" x 36" Creosoted block

Fig. 1—Method of insulating brine street mains

carries close to 400 refrigerator boxes, varying in size from 200 cu.ft. to 15,000 cu.ft., aggregating a total of 2,750,000 cu.ft. of refrigerated space.

Formerly, the refrigerating load on this system was supplied by three plants—one in Reade St., one at Harrison and Staple Sts., and the North Moore Street plant, all of which were equipped with absorption type machines. During early 1918, horizontal two-stage, or compound compression, machines driven by 1,950-volt, two-phase 60-cycle direct-connected synchronous motors were installed at the North Moore Street plant.

Power is furnished by the United Electric Light & Power Co. on a maximum 15-minute average demand of measure during a period of one week. For this reason the compressors are equipped with clearance pockets, which give a 40 per cent unloading effect, permitting closer regulation of compressor tonnage delivered to the demand of the system, so as to operate at the highest possible suction pressure.

Zero-temperature brine is cooled by two horizontal multi-pass shell-and-tube brine coolers and is circulated through the system by means of four 12-inch mains, making a dual system on the trunk lines so that in the event of a break in one pair of trunk lines the other pair will carry the load. These mains are carried under the street at a distance of from four to seven feet below the surface, properly supported and insulated with not less than three layers of one-inch hair felt. Fig. 1 shows the method employed. The mains are of full-weight wrought-iron pipe with flanged joints and ring gaskets, alternate joints being made with heavy cast-iron sleeves and calked with lead. Expansion joints of the corrugated type are introduced to take care of the initial movement of the pipe. Great care must be exercised in construction to keep the losses of brine at a minimum; leakage is always a problem in a large pipe-line system. The normal losses of brine in the system average about a half-barrel a day, while the losses by accidents over which the distributor has no control is about double this amount. The specific gravity of the brine is kept at about 1.23, and the solution is tested several times a year and kept slightly alkaline. No trouble is experienced with deterioration of the mains, some of which have been in service over 30 years.

Steam pumps were replaced by centrifugal pumps to circulate the brine throughout the system, which during summer conditions requires about 3,000 gal. per min. giving a brine velocity in the mains of about 250 ft. per min. The pumps are designed to give maximum efficiency over a rather wide range of head to take care of increasing business and changing load.

In a brine-circulating system there are losses due to the indirect method which do not obtain in a direct-expansion system, such as the lower operating back pressure to the compressor the cost of brine pumping and the consequent heat delivered to the brine through pumping. However, this is offset by features of safety, simplicity and a more uniform suction pressure to the compressor, by having the ammonia confined to brine coolers under immediate control. Also, in the event of a shutdown the refrigerator coils will hold the frost much longer before dripping.

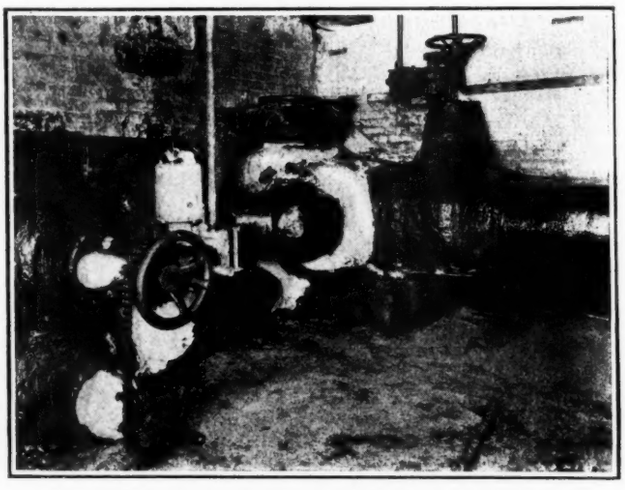


Fig. 2—Brine-gate valves electrically controlled

The question of rates for pipe-line refrigerating service is always one for discussion, and such rates vary

*Extract of paper presented at the Twentieth Annual Meeting of the American Society of Refrigerating Engineers, in New York City, Dec. 2, 1924.

†Engineer, Merchants' Refrigerating Co., New York City.

as much as the methods of applying them. Charge for service from central steam-heating systems is based on condensation meters or flow meters for steam used. To measure refrigeration service to individual boxes with any degree of accuracy on a brine system, so as to charge for the tons of refrigeration consumed, would require a recording flow meter to measure the quantity of brine delivered and a recording differential instrument to measure the temperature range. This, in small boxes where the range between the in- and out-brine temperature may run less than two deg. in order to get proper circulation, would give too great a percentage of error with commercial instruments. Such instruments

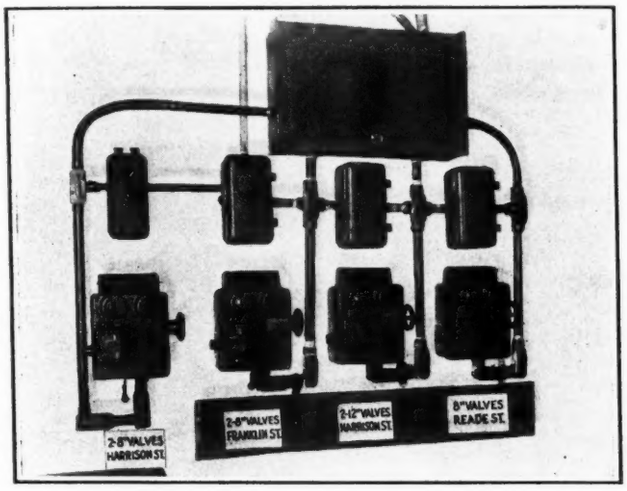


Fig. 3—Dean electrical remote-control switches

would be expensive, and the labor involved, maintenance, etc., would make measurement of refrigeration in small pipe-line boxes impracticable. A charge based on cubic feet of space refrigerated with a distinction between a freezer and cooler, which is arrived at by ratio of pipe in the rooms for normal conditions seems to be a practical way to take care of this question. The customer is required to sign a contract and a minimum charge of four months' service is made, after which the service is charged monthly and is optional with the customer.

For the same reason that a high yearly average load factor is desirable to the electric-power station, it is desirable for the pipe-line refrigerating system. Where the percentage of cooler service exceeds the freezer, or in service where temperatures below 25 deg. F. are required, the load factor will run less, because cooler boxes probably will not require service more than six months, whereas freezers require service from nine to twelve months of the year.

As continuous and reliable service must be maintained in a system upon which such a vast quantity of perishables depends, additional protection is given through a large reserve storage of strong calcium chloride solution kept at a temperature of about 32 deg. F., ready to make up any losses in an emergency. A proof of reliable service is shown by the fact that very few of the customers go to the expense of providing drip pans under the coils should the circulation go off because of any trouble and cause defrosting; a serious shutdown has not been known for 25 years. Customers desiring brine service are required to build insulated rooms, using not less than 5-inch corkboard for freezers and 4-inch corkboard for coolers, and install the necessary piping, for which they are provided specifications and secure bids in the open market. The company's inspectors see that the work is properly performed and from the time of acceptance take complete charge of the controls.

A novel feature of this system to prevent heavy losses of brine solution and the consequent shutdown of service due to a break, is the use of remote-control electrically operated gate valves. These valves are placed in the main branch lines, the motors and control stations of which are designed to operate under damp and frost conditions. All these valves are arranged for local and remote control and are tested twice a week. In the event of a break in the system the loss of a half-barrel of brine will automatically send an alarm to the engine room, and from the main control station, in the engine room at North Moore St. these valves can be closed in less than thirty seconds, thereby sectionalizing the system into four parts and confining the losses to the section in which the break occurs.

Location of the section in which a leak develops is readily obtained by the loss of pressure indicated by gages on each section, and little time is lost in getting the other sections in operation. These valves are of the iron-body, brass-mounted, outside screw-and-yoke type with solid wedge gates. The motors operating the valves are fused to blow should any sediment or foreign matter accumulate in the seat and prevent the gate going to its bottom limit and causing an undue strain on the valve body. The yokes of these valves are also weakened to break at a definite place, as a last protective resort.

The general application of pipe-line refrigeration is most successful in market districts where the demand for service is in confined territory, keeping the cost of distributing mains to a minimum for the cubic feet of space cooled. Power is the greatest item of expense, therefore the cost per ton of refrigeration delivered to the system should be kept to a minimum.

As a rule, extensive pipe-line refrigeration systems are run in connection with large cold-storage warehouses located in the market districts. This is a desirable condition and minimizes the operating expense and plant costs. As the demand for refrigeration service increases with the natural growth of business in the vicinity, it is well, therefore, to observe, when installing mains in the streets, the general direction of growth in the territory covered, so that the proper size of mains may be installed to take care of the future.

When the plant, either absorption or compression, is operated by steam, the sale of low-pressure steam for heating and commercial purposes with byproduct steam can be made profitable and tends to economy.

Pipe-line systems should be equipped with instruments to obtain data properly and records should be kept of such items as tons of refrigeration delivered to the system, cost of power to deliver a ton, etc.

There are several large pipe-line systems which are operating with electric power furnished by central stations. In New York City the rate of charge for this kind of service requires that no service in excess of 20 per cent of the highest preceding maximum demand of the year shall be required on any business day between the hours of 4 p.m. and 8 p.m. during the months of November, December, January and February.

Welded Joints in 250-Lb. Steam Line

By T. T. Copeland*

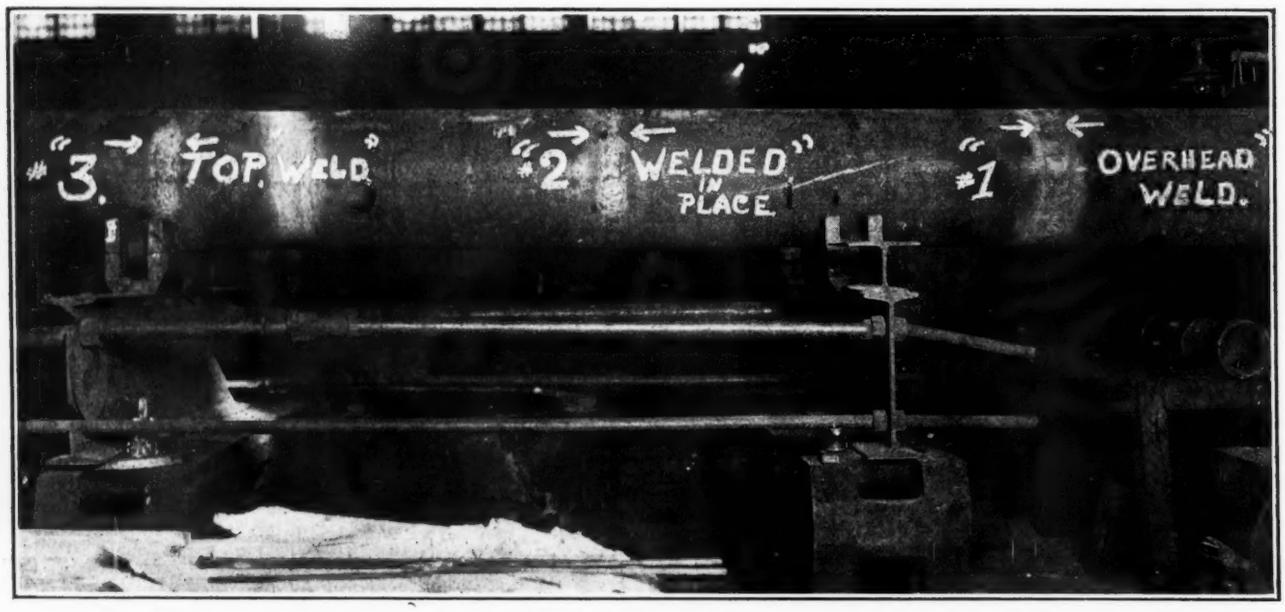
A PIPE LINE 816 ft. long, 16 in. outside diameter, for 250-lb., 500-deg. F. superheated steam, which contained approximately 45 welded joints, was completed about the middle of October, 1924. The line was tested out by turning on steam slowly through a bypass which was allowed to remain in the pipe for a considerable time after normal pressure was reached. Only one leak developed in the entire line. This was repaired by cutting out a V-shaped opening and rewelding at this point. The line was then covered and has been in constant use since November, 1924, without giving any trouble.

In erecting steam lines with welded joints, it is customary to weld as many sections in the shop as possible. Each section is tested by blanking off the ends and applying a hydrostatic test of 300-400 lb. Most welds are hammered while under test. After the entire line is completed, 50 lb. of steam is first turned in very gradually, so as to heat it up, and an examination made for leaks. After this test, pressure is gradually increased and the welds inspected until the normal pressure is reached. On account of the difficulty of testing a considerable length of steam line contained on hangers with water, such tests are made in the shop as far as possible.

The strength of a butt-welded joint, when properly made, can be gaged from the results of a test made on an 18-in. pipe, 5 or 6 ft. long. At one end a section of pipe was welded by an electric arc, as well as a head fastened by the same method into this section. At the other end a similar section was added by gas welding, and a blank head also thus welded in place. A hydrostatic test of 475 lb. per sq.in. was applied, during which time the welds were hammered. After this a large spindle was dropped several times on the sections welded together. The joints were then cut up and pulled for tensile strength. All of them measured over 50,000 lb. per sq.in., both kinds of welds being about on a par as to tensile strength.

A pipe joint made by welding a V-shaped opening with the proper equipment and by a first-class welder should be as strong, if not stronger, than the original metal itself. The cost of welded joints does not suffer by comparison with flanged joints, being notably less in large pipes for increased pressures and temperatures. Maintenance is less on account of permanent tightness.

The illustration indicates some work that is given to test the ability of a welder. The pipe joint at the right is made while welding overhead, turning the pipe around as necessary. Weld No. 2 was made while the operator worked completely around the stationary pipe, and weld No. 3 by turning the pipe while doing all the welding at the top.



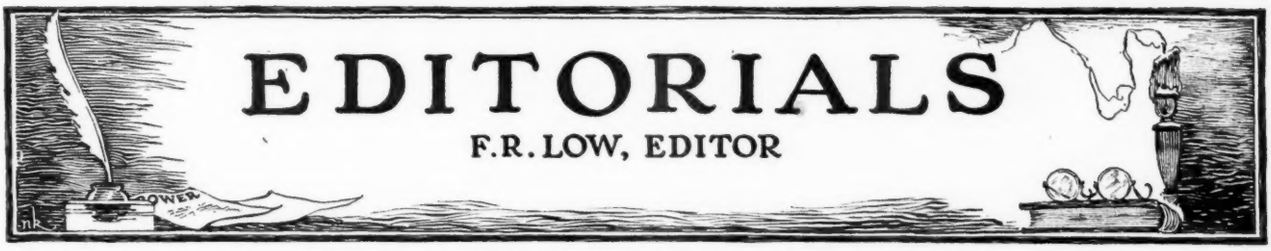
Welder's ability tested by making first weld overhead, the second one by working around a stationary pipe, and the third by welding from the top while rotating the pipe.

Elevator Governor Cables

The governor cables for any elevator should be of the tiller rather than the hoisting variety. The latter is not sufficiently pliable for proper operation over the small diameters of governor and tension sheaves, while the tiller variety is. Occasionally, objection is made to the latter on the ground that it is so soft as to slide through the governor jaws and not cause the safety to set, while the hoisting variety will not slide through. If the jaws are in proper order and adjustment, the tiller cable will not slide through.

Where the tension weight for the governor cables is swung in a bracket in the bottom of the shaft, the cables, in time, wear through the brackets, allowing the sheave to swing into the shaft. There being very little clearance between the car and the bracket, the car will strike the sheave should it swing out of plumb.

*Road Foreman of Engines, Carnegie Steel Co., Munhall, Penn.



Testing Pressure Vessels With Air

WE HAVE received several communications regarding the bursting of a tank under test in the boiler works where it had been fabricated.

As this was not a boiler, but a small gasoline tank, and no particulars as to the cause and manner of its failure from which useful deductions might be drawn were available, we have not gone into the particulars.

There is, however, one impressive lesson that the occurrence should convey, and that is the folly of testing a vessel with air or any other expansible gas or vapor under pressure. If rupture occurs, the energy that has been expended in compressing the gas or vapor is instantly released and impressed upon the immediate surroundings. In the case of hydraulic pressure the only energy expended has been that in pushing the fluid into the vessel with only the change of volume sufficient to take up its elasticity, and not enough to occasion damage should rupture occur.

It would appear from the published reports of the accident that the test was conducted to prove the tightness rather than the strength of the tank, and that some condition resulted in the application of much more than the intended pressure.

The Fundamentals Meet Any Situation

THE scientific method has an important place in the practice of engineering. Petrified knowledge never has and never can cover all the specific problems that arise.

A Canadian town was paying for its city water according to the readings of a venturi meter. This meter, normally reliable, suddenly began to show a very high water delivery with no apparent cause for increased consumption.

Investigation disclosed a stick of wood lodged in the neck of the meter. The question arose as to the fair charge to be made for water during the period when the meter was obstructed. Here was where a mixture of the scientific method and engineering horse sense came in. The guilty stick was carried off to a university laboratory along with the meter. It was a simple matter to calibrate the meter with the obstruction in place. The only reasonable doubt in connection with this calibration was removed by tests that showed a practically constant calibration curve whether the stick was allowed to find its own position or was drawn forcibly into place. It was then a simple matter to translate the graphic records made during the period of obstruction into terms of the calibration and adjust the water bill to the satisfaction of all concerned. The full story will be found on page 532.

The situation was met not by remembering some formula for venturi meters, but by an appreciation of the general scientific law that the difference in water pressure between two points in a tube of any shape obstructed by anything is a "function" of the flow. That is, there is a definite relation between rate of flow and pressure difference, and this can always be found by trial when other methods fail.

Interest

PSYCHOLOGISTS tell us that interest is the basis of success in practically every line. Certainly, it is the tap root of success in acquiring knowledge. It is safe to say, for example, that some of our best scientists had no more natural aptitude along this line than the average intelligent citizen. They were, however, carried far by a passionate interest in work of this sort, by a curiosity that had to be satisfied.

In running a power plant, the same factor stands out as all important. Without interest it is a mean job, full of trouble—the less interest the more trouble. With interest, troubles reduce and those that occur yield at least some pride of accomplishment to the man who can "lick" them. The average man seems to feel that if he displayed a lively interest in his work, by making it in fact his hobby, he would be giving his employer more than he paid for. So he refuses to become interested. This "biting off one's nose to spite one's face" is the height of folly. A wisely selfish man might demand more pay for his valuable services, but he would never deprive himself of the pleasure of interested endeavor merely to hold his employer down to his supposedly exact dues.

Plant Design vs. Operation

IN POWER-PLANT design and operation the engineers are in general influenced by two different sets of considerations. The designer, when selecting the equipment, should be guided by the economic aspects of the problem. Selection of equipment should be based on obtaining a unit of power on the switchboard at a minimum cost, consistent with reliability. Such a design does not necessarily mean that all the latest innovations for increasing efficiency will be included. Where air heaters or economizers might be justified in a central station or large industrial plant, if used in a small installation they might result in an increase in the cost of power at the switchboard, although the plant could be made to show a higher efficiency than one of a more conventional design.

After the station has been built and put into operation, the most economical results will in general be obtained by operating the plant at its highest efficiency, and to do this also means giving careful attention to the equipment's maintenance. With the exception of maintaining the furnace temperature too high, about everything that the operator can do in the boiler room to improve the efficiency of the plant will also result in improved economy.

Keeping the boilers clean, preventing steam, water and air leaks, proper control of combustion and loading of the boilers, all contribute to both the efficiency and economy of the station. If the CO_2 is maintained too high, the high furnace temperature may result in a greater cost of brickwork maintenance than the gain in efficiency is worth, but this is one of the exceptions where in a given plant increased efficiency may not produce a decrease in the cost of producing power.

What applies to the boiler room is equally true of the generating end of the plant; there are a few exceptions where increased efficiency obtained in operation does not reduce the cost of power at the switchboard. Where it is the province of the designing engineer to give careful consideration to ascertain if every piece of equipment going into the plant will result in an increase in efficiency that will warrant its installation, it is the operating engineer's job to get the highest efficiency from the equipment consistent with operating conditions.

Better Attention Be Given Before Than After

IF ELECTRICAL EQUIPMENT is to render a high degree of service, it must first of all be of good design and well constructed. Low-priced apparatus under some conditions has been known to give fairly good service, but it has also been known to fall down badly and give no end of trouble. But high-grade equipment is not the only requisite to service; it must be properly applied. It does not make any difference how well a motor or a controller may be built, if it is not suited to the service to which it is put, satisfactory operation cannot be expected.

The third requirement is that the apparatus be properly installed and adequately protected against overload and other abnormal conditions, and fourth, it must be given periodic inspections and maintained. Motors have been known to run for long periods without any attention other than somebody once in a while shooting some oil in the general direction of the bearings. In such cases machines remain in service more by luck than for any other reason, and where one piece of equipment stands up under such treatment, many fail and give all kinds of trouble.

When an electric motor or controller fails and must be repaired, the biggest item of cost is usually the loss of production and not the actual cost of making the repair. Where the cost of the repair may be an inconsequential sum, the loss in wages and manufactured product may run into hundreds and thousands of dollars. These facts should be kept in mind when considering the installation and maintenance costs of apparatus.

Some of the worst and most expensive failures of electric machinery are due to inadequate protection or to lack of proper maintenance of the protective apparatus. This is brought out clearly in the article, "Preventing Breakdown of Electrical Equipment," by C. R. Chace, on page 529 of this issue. In one case in particular a large motor-generator set was completely wrecked by the direct-current generators becoming motorized and running away. If this equipment had been properly protected with overspeed and reverse-power relays, the accident could not have occurred. It has been established that, when alternators are equipped with differential protection, in the case of a failure in the winding the damage is small compared with what it generally is where such protection is lacking. Effective as the best protective equipment may be, it can be made of little value by neglect. Good equipment, properly applied and installed and then given adequate inspection and maintenance, is not only the cheapest in the long run, but is the only way of insuring reliable service.

Cast Steel an Improved Material

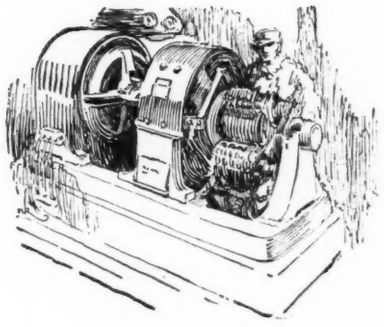
SINCE steel is ordinarily a more difficult material to handle in the foundry than cast iron, it was not unusual to find its products showing relatively more evidence of blowholes, patches, etc. While it has been possible to obtain a high grade of material, that in flanges, fittings and valves sometimes has appeared to reflect lack of appreciation of service requirements on the part of both the manufacturer and the purchaser. On the other hand, when attention finally became directed to the limitations of ordinary materials for operation at higher temperatures, the possibilities of cast steel for this service were seized upon. Great effort was spent in developing better material, design and manufacturing processes.

Several points have been brought out as a result of these improvements. The ease of control of the electric furnace has made it a valuable medium for refining steels of all kinds. Physical properties of some improved cast materials compare favorably with high-grade rolled steels, while the skin appears to equal that of the best iron castings. Perhaps the most important of all is the recently applied X-ray processes for determining voids and inclusions of foreign substances as an aid to the production of uniform metal, as described elsewhere in this issue.

Many failures in the past have been traced to internal defects. Now the Watertown Arsenal makes possible the detection of such things on a commercial basis. A notable advance in the art of making steel castings is represented by those composing the high-pressure wheel casing for the twelve-hundred-pound steam turbine at Weymouth, which was thus surveyed internally. From what was sometimes regarded as an unreliable material cast steel has been improved so that it is now well equal to the requirements of maximum steam conditions, as well as to other uses at greater temperatures. It is not unlikely that with recent advances, the field of usefulness for cast steel will be further increased.

At a recent meeting of the St. Louis Section of the A.S.M.E. Prof. E. L. Ohle, of Washington University, spoke of smoke prevention and proposed a committee of representative citizens, including consulting engineers, power-plant engineers, coal dealers, home owners and other representatives of interested groups. His idea was that this committee should investigate what has been done in other cities in the line of smoke prevention and try to evolve some practical scheme of regulation that would give reasonable protection without being destructive of industrial interests. This is a reasonable proposal. As far as the engineering side is concerned, it is essential that the best-informed and most practical combustion engineers be chosen for service on such committees. The presence of such experts would avoid foolish remedies, such as the demand that "smoke consumers" be placed in chimneys—a demand, by the way, that is often voiced by well-meaning laymen.

Practical Ideas from Practical Men



WITH a view to stimulating engineers into the habit of recording for the benefit of brother engineers, unusual occurrences, how these were met and other practical expedients adopted in the operation of their plants, Power has decided to award two cash prizes each month during 1925. One of $25 for the best and another of $15 for the second best practical letter on plant operation or practical kinks received during the month. This is in addition to payment for the contribution at space rates. The winners for February will be announced next week

Incorrect Assembly of Governor Causes Flywheel Explosion

A few years ago the chief engineer of a light and power plant in the South was killed through the bursting of a flywheel on one of the engines due to overspeed, it being later revealed that the overspeed of the engine had been caused by incorrect assembly of the governor. The engineer had previously held the position of superintendent for a manufacturing company, building engines and boilers, and I was machine shop foreman under him. He was a capable man and considered a high-class engineer. It so happened that the position of chief engineer was offered to me and I accepted, taking charge two weeks after the accident.

The generating units consisted of three compound-condensing engines of 500 hp. each, the one that was wrecked being a twin-tandem-compound. Upon examining the wrecked engine, I found that the valve motion had been partly destroyed, but no damage had been done to the cylinders, bedplates, shaft or connecting rods.

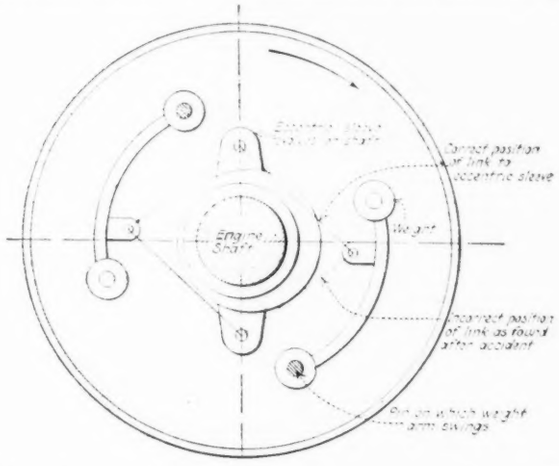
The manager stated that immediately after the accident he had wired to the manufacturer of the engine to send a man to ascertain how much damage had been done and what had caused the accident. The man, after spending considerable time making a careful examination, reported there was no visible reason why the engine had raced except that the flywheel was broken; it might have been caused by the valve gear getting out of order before the accident; he could not say, because the valve gear was broken and how much was broken before or after could not be determined. He had looked over all the valves on each engine and they were found in perfect shape. The governor was intact, nothing missing or broken.

The manager, after receiving the report, gave the man an order to his company for all new parts needed, including a flywheel, and with the exception of the latter all the repairs were on hand when I arrived to take charge of the plant.

In order to be on the safe side, as there was nothing to show what had caused the accident, I decided to make all the repairs myself and also make another examination of other parts of the engine. After replacing the broken parts of the valve gear, I suggested to the manager that we run the engine for a little while without the flywheel, to find out what speed the engine would make with the broken parts removed. I also suggested that I handle the throttle valves and that he check the speed with a stop-watch. The engine was supposed to have a normal speed of 165 r.p.m.

The engine was allowed to come slowly up to speed, and before the governors had made any appreciable change on the valve gear the manager called out 170 r.p.m. I tightened the throttles slightly and at the same time watched the governor weights. It was at once seen that the weights had been out to the rim of the governor wheel and had returned to the stop without moving the cutoff valves. Here was the secret of the trouble.

We then removed the springs from the governor and



Shows incorrect position of governor connecting links as found after accident

moved the governor weights in and out by hand. There was only about ¼ in. movement back and forth of the cutoff valves, but no positive motion in the direction the valves should move to cut the steam off completely when no load was on the engine. Here was a puzzle. Suddenly it occurred to me that probably the connecting links on the governor were connected to the wrong pins of the eccentric sleeve. Accordingly, I reversed the links, as illustrated by the solid and dotted lines in the illustration.

When this had been done, we started the engine again and found that with the throttle wide open the engine ran at 163 r.p.m., this being positive proof that, with some slight adjustments, the governor was connected properly.

To sum up the case, it seems that the engine had been stopped for repairs. A local repair shop had sent men

over to do the work and the engines had been partly dismantled, including the governor. When the repairs were completed, the engine was run at half speed a few hours to smooth down the new bearings. At the end of that time the engine was brought up to speed, but before the engineer realized that the governor was not functioning properly, the flywheel burst, killing him instantly.

The relatives of the chief engineer brought a damage suit against the company, and trial took place before a jury. After the plaintiff's lawyer and defendant's lawyer had presented and defended, respectively, their case, witnesses were called. Later the judge excused the jury while the lawyers had an argument over technical details. Then the jury was recalled and the judge ordered them to render a verdict in favor of the defendant, stating that the chief engineer had been employed by defendant as an expert in such matters and should have known whether or not the engine was safe to run. It was also stated if anyone else (presumably even the man that connected up the governor wrong) had been killed, the company would have been liable to damages.

F. C. BLOMBERG.

Little Rock, Ark.

Installing Air Compressors Temporarily on a Cinder Fill

During the construction of a large power plant, the site of which was soft meadow land adjacent to a river, it was found necessary to place the air compressors temporarily on a location that had been cinder filled to a depth of about seven feet.

The proposed site was probably the best in the neighborhood, and while piles were necessary for a sounder job, conditions at the time did not permit of them. In addition, there was the possibility that upon the removal of the air compressors to permanent positions, the temporary site would be speedily required for other purposes in an unencumbered condition.

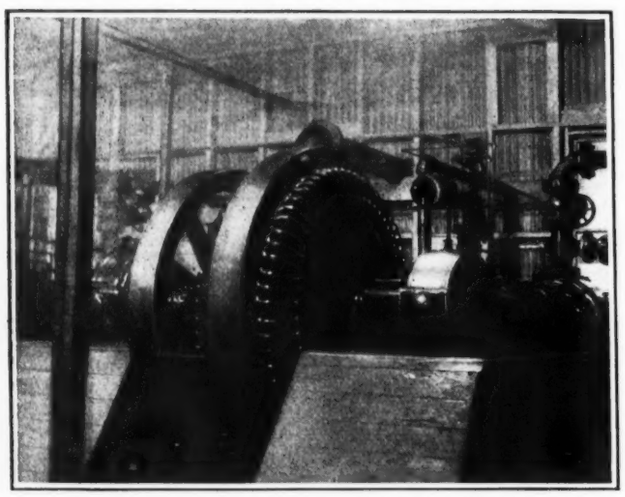


Fig. 1—View of one compressor

After taking the different points into consideration, it was decided that a timber foundation would best meet the case, the more so since one of such a type could be ripped out within forty-eight hours.

Old pile butts were used to crib the footing thoroughly and upon this was built the foundation, of 3x12 in. yellow pine, machine planed and laminated throughout to prevent warping. Fourteen 1¼-in. through bolts with 4-in heavy cast washers were added to reinforce the bearing pedestals. The regular foundation bolts, as required for concrete, were replaced by longer through bolts and 3-in. pipe sleeves were driven full depth to obtain greater rigidity.

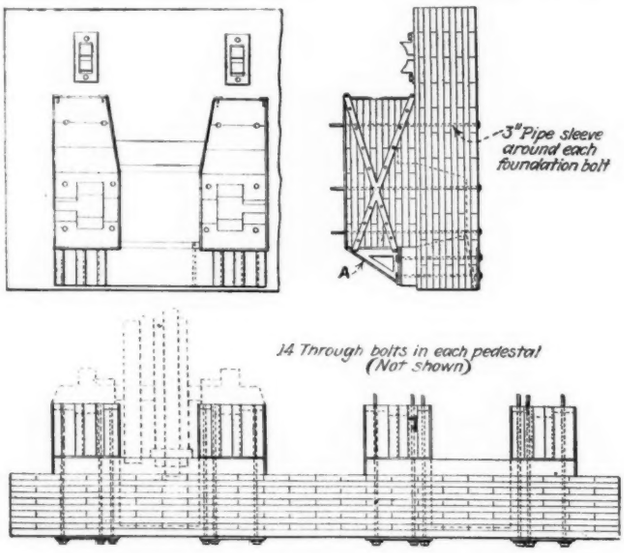


Fig. 2—Details of timber foundation

To further strengthen the side pedestals, three 4x4x½-in. angle-iron braces *A* were placed at the crank end of each pedestal and firmly bolted through the foundation, ¾ in. thick steel plates being added as shown.

Flat ½x3-in. steel diagonal straps were then fixed along the sides of the pedestals, which had ¾-in. thick end plates and were further held by 6-in. lagscrews placed at suitable intervals. It will be noticed that only one end is braced; this was on account of the first cooler location, which made double end bracing undesirable.

Fig. 1 is a general view of one of the units, and Fig. 2 shows the details of the foundation.

The compressors are of the duplex, direct-connected type, running at 257 r.p.m. each having a full load capacity of 520 cu.ft. of free air per minute. Power is supplied through a 2,300-volt synchronous motor.

Nearly ten months have elapsed since these units were put into operation (a longer period of time than was anticipated), and results have been extremely gratifying.

C. S. GRIGOR.

Hoboken, N. J.

Pump Plunger Rod Repair

An easy way to repair worn and badly fitted steel plunger rods on pumps is to take a hard bronze tubing ⅛-in. thick of the same outside diameter as the steel rod. Take the rods out of the pump and turn them down until the bronze tubing can be driven over them. Face the tube to a tight fit between the crosshead and the piston or plunger.

This will give a rod that will wear better and be easier on the packing than a new steel rod, and at only a fraction of the cost. I have tried this plan and it works to perfection.

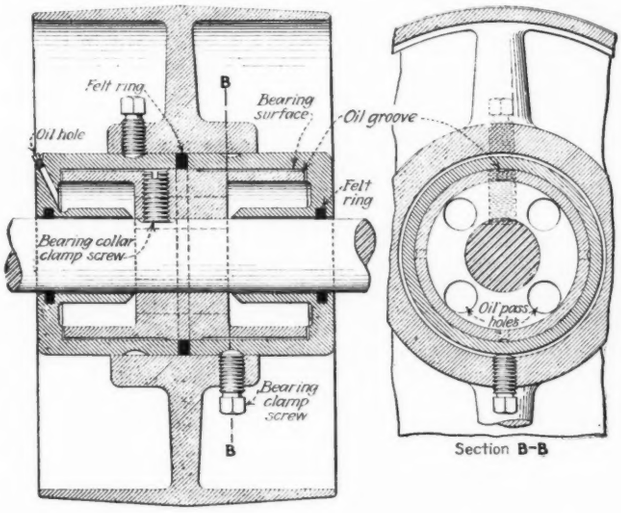
ROY E. SUTTON.

Abilene, Kan.

Construction of Loose Pulley Having Large Oiling and Wearing Surfaces

The illustrations shows a loose pulley having a large oiling chamber and a large wearing surface. The pulleys are all bored one size, while the collar which is clamped to the shaft and on which the bearing sleeves run, is bored to the size of shaft on which it is to be used. The collar and sleeves are the wearing surfaces and are made large in diameter.

The pulley is designed to run for long periods with one oiling. It was made for a machine on which the loose pulley gave a great deal of trouble, it being used on a continuous shifting device. This type of pulley would be practical where a large number of pulleys are used, as the pulleys would be all bored to one size and the sleeves and tightening collar could be bored



Pulley designed to run long periods with one oiling

and stocked for the various sizes of standard shafting, while the outer diameter of the tightening collar and the sleeves would be a standard. Four oil grooves, as shown, are cut in the bearing surface and in the sides of the bearing collar, to insure the oil from the chamber reaching the bearing surface. HUGH HUMPHREYS.

Grand Rapids, Mich.

Operation Comparison of High- and Low-Pressure Boilers

Some years ago I was connected with a utility company that owned a number of central heating, gas, and electric plants and operated a number of isolated plants that generated electricity and utilized the exhaust steam for heating. These plants were scattered in a number of small towns. The company extended a transmission line that made it possible to close down the generating units and furnish the electricity from one large plant. The small plants had to be operated for heating, so the boilers, which had been operated at pressures from 150 to 250 lb., were changed to operate at 15 lb. or less. For two years the plants were all operated at low pressure, and a complete record was kept of the many items that entered into the cost of operation. The efficiency fell off so much during this period that it was decided to change back to high pressure, which proved to be more economical and satisfactory in every respect.

The change from high to low pressure made it impossible to operate steam-driven boiler-feed pumps, so it was necessary to install motor-driven pumps. The soot blowers could not be operated, and it was necessary to clean the soot off by hand. Then the water-tube boilers could not be turbined with low-pressure steam, which again made it difficult to keep the boilers clean. The steam ash-handling systems at the different plants could not be used and the ashes had to be handled by hand, all of which increased the operating costs. Several of our customers required high-pressure steam for cooking and process work, and when we could no longer supply their needs, they changed to gas for such uses. After two years of low-pressure operation at a big loss on the sale of steam, the company changed back to high-pressure and at the same rates made a profit by serving the same load under the same operating conditions. The results were so much in favor of the high-pressure operation that we conducted exhaustive tests at both pressures and proved to our satisfaction that the high-pressure operation was more efficient and economical.

After changing to high pressure for two years, our customers who were using gas for process work and cooking took high-pressure steam for these services and low-pressure for heating, all of which increased our business about 35 per cent. In time our customers expressed a desire to generate their own electricity, and we were compelled to start up the engines and sell them the exhaust steam. In high-pressure processes that required pressures up to 100 lb., we were obliged to install highly efficient turbo-generators that would generate electricity and furnish exhaust at 100 lb. pressure. In cases where there was sufficient steam flow and a sufficiently high initial pressure to give a reasonable heat drop, back pressures in excess of 100 lb. were found perfectly practical. The installation of such equipment made it possible to generate electricity at a fuel consumption of 0.58 lb. of coal per kilowatt-hour as compared with 1.50 lb. per kilowatt-hour at our large power plant running condensing. By using the turbine as a reducing valve and using a considerable quantity of the exhaust for manufacturing purposes, the turbines paid for themselves within three years.

Economies were worked out to such a fine point that the customers became suspicious, and when a contact was ready for renewal the customers expressed a desire to take back their plants and pay for the equipment we had installed in their boiler rooms. In order to secure new contracts we were obliged to pay from $2,000 to $15,000 rebate, which we met by paying for the use of the boiler rooms. By this plan we continued to operate the boiler rooms, and we took on adjoining buildings, furnishing electricity and steam from the one boiler room to the entire business block. This plan was so successful that it was worked out along parallel lines in many other cities.

Where the utility company refuses to take on this class of business and pay a rebate in the form of rental, then the block plant finds it more profitable to operate as an isolated plant using the engine as a reducing valve and generating electricity and heat for less money than they could be purchased from an outside plant. H. A. WOODWORTH.

St. Louis, Mo.

Comments from Readers

Do Water-Cooled Furnace Walls Increase Boiler Efficiency?

During the last year or two the use of water-cooled furnace walls in steam boiler plants has increased considerably as the result of an effort to reduce the maintenance expense on refractory furnace walls. At the same time the impression has been made on a great many people that the use of water-cooled walls increases the amount of heat absorbed by the boiler, and therefore increases the "boiler efficiency," meaning the efficiency of boiler, furnace and grate. I am not prepared to comment on the effect of water cooling in reducing furnace-wall maintenance expense, but I do question the conclusion that additional water-heating surface in the combustion chamber necessarily improves the heat-absorbing capacity of the boiler as a whole.

The heat absorbed through water-heating surface in the form of water-cooled walls is transmitted in the same manner as that absorbed by boiler surface proper; namely, by radiation and by convection. The heat transmitted through water-cooled walls by convection may be assumed to be insignificant in amount, for two reasons—the extent of such surface is seldom more than a very small portion of the total boiler-heating surface, and water-cooled wall surface is poorly adapted in both location and arrangement to receive heat by convection.

Heat transmitted to water-cooled wall surface by radiation is by no means insignificant in amount, but on the other hand it consists almost entirely of heat that would otherwise be radiated indirectly to the heating surface of the boiler proper. Suppose for the moment that the water-cooled surface were replaced by refractory. This refractory surface would absorb part of the heat radiated from the fuel bed, or in the case of pulverized fuel, from the incandescent particles. A small portion of this heat—not more than 1 per cent in the case of a well-constructed wall—would be radiated to the atmosphere; the remainder would be radiated inside the furnace and absorbed by the boiler-heating surface, the other furnace walls and the fuel bed. The heat radiated to the fuel bed would increase its temperature and might either improve or reduce combustion efficiency, depending on the fuel used and the method of firing. At any rate this heat would not be lost and would eventually find its way to the boiler-heating surface; and the same may be said of the heat radiated from one wall to another.

It may be stated, therefore, that water-cooled surface in furnace walls will not increase to any significant degree the heat-absorbing capacity of the boiler as a whole, including the water-cooled walls, except so far as it reduces the amount of heat radiated to the atmosphere and absorbs heat by convection.

There are, as yet, few if any published data showing the thermal effect of water-cooled furnace walls, but I am familiar with a boiler test that showed that a change in the extent of heating surface in the combustion chamber has little effect on the total heat absorbed by such surface. During this test the boiler baffling was changed so as to reduce the amount of surface in the combustion chamber to one-half its original extent, and it was found that at the same ratings on the boiler the change in extent of heating surface had practically no effect on the amount of heat absorbed in the combustion chamber; in other words, each square foot after the change absorbed heat at practically twice the rate it did before the change. The results of this test seem to corroborate in a measure the conclusions of the foregoing analysis. JULIAN HARVEY.

Detroit, Mich.

The Master Mechanic

A number of letters have appeared in *Power* commenting on the "Foreword" in the Aug. 26, 1924, issue on the Master Mechanic.

As one who has had twenty-five years' experience as a general master mechanic, I would like to elaborate a little on this subject. After reviewing what has already been said there is, in my opinion, but one question to settle. That is, Shall the master mechanic come to work, put on greasy overalls, then start to run from one thing to another, or shall he come to work neat in appearance and enter what is known as the master mechanic's office (one that is neat and clean), look over all the reports that were made in his department the day before, then file them, if no change has been made, in a suitable place where they can readily be found if needed?

He should then go into the works and consult the different foremen, reviewing in a businesslike manner, every subject that is likely to come up that day. This being done, he should return to the office where the following work should be kept up to date: All blueprints should be folded to some standard size (not rolled in a bundle) and kept in a cabinet for this purpose. A card index should be kept that will tell in which file any blueprint can be found, also an index that will show when any repairs were made and the time required to make them, also any changes that have been made in the power houses. In connection with these, there are other reports that should be kept up daily (in the mining of iron ore), the amount of coal used, gallons of water pumped, cubic feet of free air used, also the kilowatts delivered to the switchboard, which should be checked up with the coal used and compared with previous records.

It is usually the duty of the master mechanic to design the guards used on machines and to see that they are put in place and kept there, also to instruct the workmen daily in the hazards of their work. A certain amount of time should be spent each day if possible in reading the mechanical papers. He should read all articles that have any bearing on the equipment that he has under his charge. It is important that every page of advertisements be looked over, as

that will help him to keep informed with what is being done in the engineering world.

In the "Foreword" previously referred to, the question is raised, Why is the master mechanic the master hand and the master mind in times of accident and confusion? These qualifications would make him a leader, and leaders are ordinarily persons with extraordinary determination, which accounts for the master mechanic, as mentioned in the "Foreword," having some spare time to be "sunning himself on the doorstep."

Norway, Mich. THOMAS PASCOE.

Why Do the Indicators Give Different Diagrams?

The article by R. G. Summers in the Dec. 16, 1924, issue and the comments by Earl Pagett in the Jan. 27, 1925, issue on the same subject are interesting.

Mr. Summers says that 60-lb. springs were used in both instances and that the load conditions were the same. If these statements are correct, the evidence points to faults in the new indicator and not the fact that one indicator cord was longer than the other, as Mr. Pagett suggests. In the crank-end diagram shown in Fig. 2 of his article, the expansion line indicates a rather sharp decrease in pressure and intersects the head-end expansion line nearest the left-hand side of the diagram. In Fig. 1 this expansion line is gradual and intersects at a greater distance from the left than in Fig. 2. It is possible that the drum did recoil against the stop giving the vertical line on the head end as Mr. Pagett suggests, yet, while it is possible to get two diagrams of different lengths under these conditions, it is highly improbable. At any rate the cord length has nothing to do with the difference in height of the two diagrams. It is obvious that if the drum did recoil to the stop, there was sufficient slack in the indicator to be noticeable. Also, the end of the diagram would have been very close to where the card was slipped under the clip and either case would serve to show something wrong and need for adjustment of the cord. It is my opinion that the new instrument was sluggish in its action and failed to respond to the

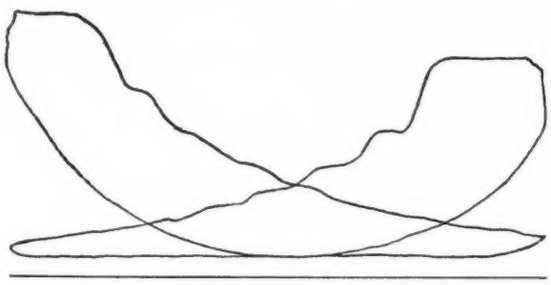


Fig. 1—Diagram taken with new indicator

steam pressure or the spring, although this was not to the extent of making the lines of the diagram jerky.

During last summer I had an indicator experience under similar conditions, and two diagrams taken at the time are shown herewith. These diagrams were taken from the high-pressure cylinder of a 225-r.p.m., four-valve cross-compound engine direct connected to an alternator. Having a desire to get diagrams from this engine under light load conditions, the indicator was warmed up at the same time as the engine and after putting the machine on load I got the diagram shown in Fig. 1, which was the seventh diagram taken with the new indicator. When taking the diagram I noticed that considerable pressure was necessary to bring the pencil arm against the card, and the diagram was very irregular. I changed indicators immediately, using an old one I had just finished cleaning, and got the diagram shown in Fig. 2 with a load of 20 kw. It will be noticed that in the diagram Fig. 1 the trouble seemed

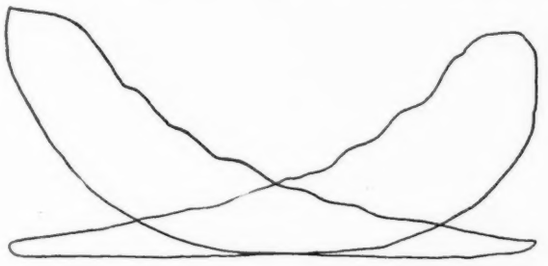


Fig. 2—Diagram obtained with old indicator with engine operating under same conditions

to be mostly, the inability of the spring to overcome the friction sufficiently for the indicator piston to follow the gradual decrease in pressure along the expansion line. A method I sometimes employ in indicating engines is to use two indicators connected as close together as practical on a tee connection leading from the three-way cock, an additional cock being used with each indicator.

In Mr. Summers' case it may be possible that the cord came in contact with the cylinder on the stroke in question, the cord striking just right to prevent the indicator drum following the rest of the engine stroke.

Fort Terry, N. Y. ROBERT H. LARKIN.

Aluminum Paint in the Power Plant

Having had considerable experience with aluminum paint, I should like to add to the points brought out in the editorial on this subject in the Jan. 27 issue.

On account of its heat-resisting qualities aluminum paint is proving to be an efficient material for a variety of purposes in power and industrial plants. Aluminum paint has a covering or hiding power excelled by no other paint and is an excellent protective coating for iron and steel. Thus it can be effectively applied to steam lines, pumps, pipe fittings, steel chimneys, tanks, valves, ventilators, etc. No special preparation is necessary beyond removing all rust, grease and dirt from the surface to be painted.

Aluminum paint is usually supplied at the right consistency to use, but if it requires thinning, then only the special thinning preparation should be added. This preparation is obtainable from most paint dealers, and unlike turpentine or its substitutes, it does not dull the bright luster of the paint.

When required to resist heat, the paint should be well brushed about until it is practically dry, the object being to remove all traces of liquid and to work the bright metallic particles into the iron or steel parts under treatment. One coat of paint is sometimes sufficient, but two coats, of course, make a better job. In any case the paint should be applied somewhat spar-

ingly. This is particularly desirable when the paint is required to withstand heat.

By means of the process of metallization it is possible to coat any solid substance with an impervious layer of aluminum, of any thickness from 0.001 in. upward. The process embraces the melting and atomizing of the aluminum or alloy, which is in wire form, and impinging it as a fine spray onto the surface to be protected. In this process the apparatus used is like a large pistol which is connected to suitable gas and air supplies, the former providing the means of combustion and the latter the motive power of the automatic feeding device. The wire used is 0.030 to 0.040 in. in diameter and is automatically drawn forward from a reel in the pistol case and fed uniformly and continuously into the nozzle, where, upon entering a continuous reducing flame zone, it is melted or disintegrated and carried to the work by the air blast at high velocity in the form of a fine spray or metallic dust. The velocity is approximately 3,000 ft. per sec. Without the high pressure of compressed air the metal surface would become deposited with a splashed mass. As it is, the atoms are propelled separately and get deposited very much as they may be by electro-deposition. The aluminum coating does not contract, crack or chip off.

The following are a few of the purposes for which the metalizing process may be advantageously employed: The metalizing of cast-iron, steel and wrought-iron structures, tanks, pumps, etc., to prevent corrosion by vapors; the coating of firebars, surface of boilers, retorts, radiators, etc., as a protection against corrosion by heat, clinkers, vapors and gases.

A satisfactory aluminum paint for outside work can be made by mixing 2¼ lb. of what is known as standard varnish polished aluminum bronze powder with one gallon of spar varnish, thinned with about one pint of mineral spirits so as to give a smoothly spreading paint.

It has recently been discovered that a mixture of aluminum powder and sodium-silicate solutions can, under certain conditions, be made into a very satisfactory weatherproof paint, capable of resisting abrasion to a remarkable extent. E. ANDREWS.

Manchester, England.

Problems of the Operating Engineer

I have been in the operating game for twenty-five years, but there are some things that I simply cannot figure out. I was visiting recently in a small water, ice, light and power plant of about 300 hp. There was in charge of the plant, an exceptionally capable chief engineer who had the day shift with only a negro fireman for help. At night there was a negro who was the whole works, fireman, engineer and oiler. While I was visiting there the day negro fireman showed up drunk and the chief sent him home.

As there was no extra help about the plant, the chief had to do his own firing. He went through the shift with 1,100 lb. less coal than the fireman had been using. A few nights after this the night man was sick and the chief ran his shift through. He used 1,350 lb. less coal than the regular night fireman had averaged. This was a total of 2,450 lb. less coal in twenty-four hours than the regular firemen used. They were paying these negroes $2.50 per day of twelve hours. This chief had been trying for months to convince the manager that more efficient men at a higher wage would save more than the difference in salary. The manager stuck to his old firemen because he said that they had been with him for years and could be depended on.

The coal saving possible by intelligent firing, was proved by this chief, by actual demonstration, to be around $12.50 a day. The year before, this plant had an engineer at a salary of $1,500. The plant lost during the year something over $3,000. They made a change, employing the present chief at a salary of $2,400. The profits for 1924 were over $7,000. At the beginning of 1924 the plant was in debt $18,000 and at present owes less than $10,000. A few days ago the directors held a meeting and because there was no cash dividend in sight they ordered the chief's salary cut to $150 a month with free water, ice and light. Of course he is leaving them, as he says that after the showing he has made, he could not keep his self respect and stay.

The plant is a small one, but because of its location away from machine shops, the class of help obtainable, character of service rendered and the fact that it is a combination plant with the engineer necessarily having to be a machinist, electrician, steam and refrigeration engineer, it requires a good man. I have known this man for twenty years, know that he hasn't a bad habit, is honest and thoroughly competent. The job was represented to him before he went to it as a man-killing job, but by hard work he has got things in such a condition that he has an easier time than his predecessors had. And I honestly believe that because they see him with a clean shirt and overalls instead of looking like a grease ball all the time, they think he is not earning his salary. Can someone tell me what an engineer can do to help himself? Organizations cannot help a fellow much in these rural communities where a large proportion of the steam plants of the country are in operation. This man belongs to all of the larger organizations. This is not an exceptional case, but is only one of many that have come under my observation.

Now this man is one of the best in his class. He spent a considerable sum to move his family to the town. His children are in school and he has bought a home. It will be a great sacrifice for him to move, and while there are hundreds of good jobs in this country and employers that would be glad to get him, he does not know who they are, nor do they know where he is, and he will be slow in finding a job that pays a salary commensurate with his ability, one that will allow him to live decently, educate his children and save a little money. And a man who does not get a salary that will cover these items cannot do his best. To give the best that is in him, a man must be free from the worry of trying to make both ends meet; he must be free mentally that he may concentrate his mind on his employers' interests.

Another thing is, this man will apply for another place, giving his present employer as reference (with his consent). When the inquiry comes the manager will undoubtedly reply to the inquiry and recommend him very highly, but the recommendation will be couched in such words that the reader willl feel that there is something withheld. The man will fail to get the place and will never understand why. If someone can tell me what a man is to do under such circumstances, what incentive he has to scheme and plan for his employers' interests when such conditions exist, I surely will appreciate it. C. A. HANNA.

Columbia, S. C.

Questions and Answers

Conducted by

Franklin Van Winkle

Use of Boiler Supports for Building Loads

Is it considered good practice to utilize supporting columns for boilers and combustion chambers to carry the roof of a boiler house? *R. N.*

While such boiler supports should be properly protected from heat and might be designed to carry the load of a roof in addition to the weight of boilers and settings, most laws and ordinances for the safety of buildings require building supports to be independent of supports or settings for boilers.

Identifying Dangerous Fire Crack

How can it be known whether a fire crack in a boiler shell is dangerous? *C. S.*

A crack in a boiler shell always should be regarded as dangerous until it is determined that it amounts to no more than a skin crack or cracking of the thin shell-like surface of the material. As soon as a fire crack occurs, clean off the plate with a sharp flat file sufficiently to remove the skin about one inch each side of the place where the surface crack appeared, and after moistening the smooth brightened surface with kerosene, strike all around the brightened surface with a sounding hammer. Careful inspection then will reveal whether the crack extends into the body of the plate, and if that is the case, the crack is dangerous.

Larger Safety Valve for Lower Boiler Pressure

Why will a boiler require a larger safety valve for service of low-pressure than for a high-pressure steam? *C. S.*

The weight of water evaporated by a given boiler from feed water of a given temperature, and other conditions the same, is greater for the generation of steam at a lower pressure than at a higher pressure. In addition the density of the steam generated is less, so that at the higher pressure the volume of steam to be discharged by the safety valve is less per pound of feed water that may be evaporated, and this combined with the higher velocity of discharge through the safety valve due to higher pressure, requires a smaller valve aperture to discharge the steam as rapidly as it can be generated at the higher pressure.

Motor Assisting Waterwheel

Can a waterwheel be run with an electric motor belted to the same shaft to obtain more power? *L. Z. A.*

There is no reason why a waterwheel and an electric motor cannot be operated to drive the same shaft. The division of load between the two sources of motive power will have to be controlled by adjusting the governor of the waterwheel. It would be a good idea to install an ammeter in the motor circuit so that at all times the load on the motor can be determined. However, after the proper division of load is obtained between the two sources of motive power by adjusting the governor on the waterwheel, no further adjustments should be necessary except so far as may be required to overcome any defects that may develop in the governor due to wear or otherwise, or to changes in the motor-speed characteristics due to a change in frequency or voltage of the supply circuit.

Steambound Pump

What is meant by the statement that a pump has become steambound? *C. R. D.*

The term steambound means that in place of the pump cylinder and suction chamber becoming filled with water during a suction stroke, one or both become wholly or partly filled with steam produced by evaporation of part of the suction water. This results from obtaining a suction pressure that is lower than the highest pressure at which water will vaporize when at the temperature of the suction water. Consequently, to prevent a pump from becoming steambound it is necessary to supply the suction water under sufficient head to prevent reduction of the cylinder suction pressure to that pressure of dry saturated steam whose temperature is the temperature of the suction water.

Lap Cracks in Boiler Shells

Where would a lap crack be found, and how could one tell if there was such a defect? *T. B. B.*

Lap cracks are likely to occur in cylindrical boiler shells along lap seams of longitudinal joints, from repeated bending of the shell plates that results from the tendency for the shell to assume true circular form as often as the boiler is subjected to an increase of internal pressure. This bending is accompanied by a hinging action around the edge of the overlapping plate and may result in the formation of a crack inside or outside of the boiler, on the side of the plate opposite to the side covered by the overlapping edge, or on the same side under or near the overlapping edge. By careful internal and external inspection of the boiler shell along a longitudinal lap joint the full width of the lap, it can be determined whether a crack has formed in the parts of the plates that may be examined, but cracks under the lap, which do not extend clear through to the uncovered surface of a plate, cannot be discovered until the lap has been removed or the joint has become ruptured.

Cables for Traction Elevators

What kind of cables are considered best for 2 to 1 traction elevators; what is the difference between a crucible steel 6x19 standard hoisting cable and the special traction-steel cables; and would plow-steel ropes give satisfactory service on 2 to 1 traction elevators? *J. J. P.*

There is a wide variety of cables used on traction elevators, and in the present state of the art it would

be impossible to say which is the best. In elevator service there are many conditions affecting the life of cables, such as the diameter of the sheaves, condition and shape of the grooves, the number of bends and their direction, car speed, height of travel, etc., all of which makes it difficult to decide what would be a reasonable length of life of the cables. If it is decided to use a certain manufacturer's product, it will be best to use what he recommends for a given service.

One manufacturer may supply a ⅝-in. 6x19 crucible-steel cable, where the traction sheaves are 36 in. or greater in diameter, and a 8x19 Seale type (wires of two different sizes in the strands) for U-groove sheaves, that are less than 36 in. in diameter and for all types of V-groove sheaves, while other manufacturers recommend special traction-steel cables both of the 6x19 and 8x19 construction. However, a crucible steel 6x19 standard hoisting cable and a special traction-steel cable may have different meanings with different manufacturers but it may be stated that a special traction-steel cable is one in which the wires have been specially treated in the manufacturing processes to give the cable qualities suitable for traction-elevator service.

Plow-steel ropes are not recommended for traction-elevator service of any kind. Flexibility with wire of a size that will not be worn off too quickly are qualities in traction-elevator ropes that are of more importance than great strength, such as possessed by plow-steel cables. The rope should not be so hard as to cause undue wear of the grooves in the sheaves. To obtain these desirable qualities in traction-elevator cables has led to the development of cables of the so-called special traction-steel types.

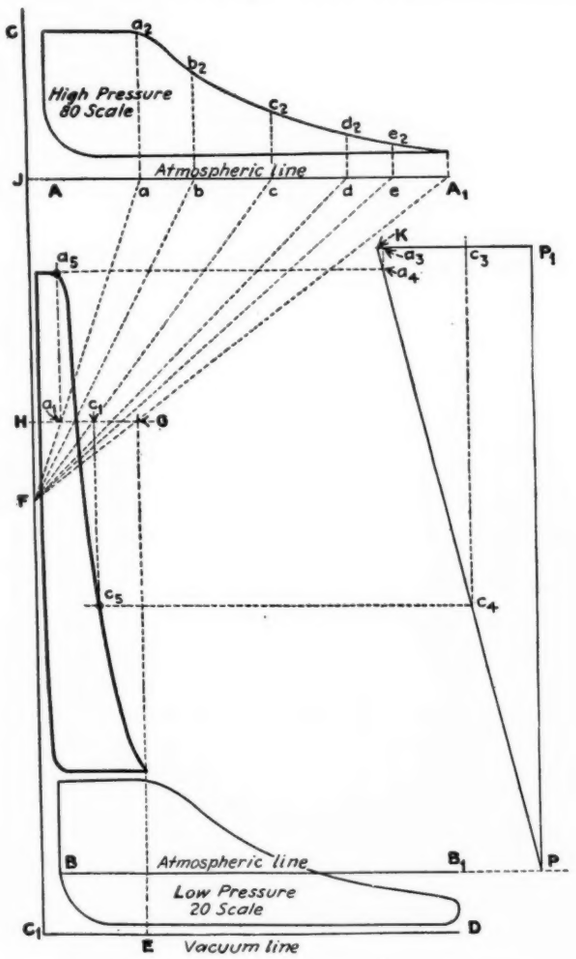
Combining Diagrams of Compound Engine

How are the high-pressure and low-pressure diagrams of a compound engine combined for the purpose of comparing the diagrams with the action of steam in a single cylinder? *W. B. G.*

The diagrams must be reduced to the same horizontal scale of volumes and the same vertical pressure scale. The scales of volume and pressure of either diagram may be taken as the standard, but the usual method is to reconstruct the high-pressure diagram to the volume and pressure scale of the low-pressure diagram. Referring to the illustration, suppose the low-pressure cylinder is twice the diameter of the high-pressure cylinder, each with 5 per cent clearance, and that the high-pressure diagram is made with a spring scale of 80 lb. and the low-pressure diagram is made with a spring scale of 20 lb. as indicated in the sketch.

Place the high-pressure diagram above the low-pressure diagram with the respective atmosphere lines AA_1 and BB_1 parallel, each with the clearance set off by the same vertical line CC_1. The actual relative volumes of the cylinders will be as 1.05 to $1.05 \times 2^2 = 10.5$ to 4.2. Supposing that C_1D, the length of the low-pressure diagram, is 4.5 in., set off $C_1E = \frac{1.05}{4.2}$ of $4.5 = 1.125$, or $1\frac{1}{8}$ in., for the length of the high-pressure diagram reduced to the volume scale of the low-pressure diagram. To any point F in the clearance line draw A_1F, and through E draw a perpendicular intersecting FA_1 at G, and through G draw the horizontal line HG. Then as $HG = C_1E$, lines drawn from points a, b, c, d, e, to F will divide HG in proportion to the divisions of the line JA_1, so that in the reduced volume diagram a volume Ja will be represented by Ha_1; Jc by Hc_1, etc.

As the scale of spring of the high-pressure diagram is 80 and that of the low-pressure diagram is 20, the heights representing pressures at different points of the new high-pressure diagram must be four times the heights of corresponding points in the original high-pressure diagram. At any convenient scale set off the perpendicular PP_1 above the atmospheric line BB_1 of the low-pressure diagram, and at right angles set off the horizontal line P_1K equal to ¼ of PP_1. Then to locate



Combining diagrams of compound engine

a point on the new diagram to correspond with a point like c_2 which is vertically over c, lay off $P_1c_3 = cc_2$ and from c_3 drop a perpendicular intersecting KP at c_4. Then as c_4 will be at the right height for the point which will correspond with c_2, and as Hc_1 represents the volume Jc including clearance, the point c_5 which is at the intersection of a perpendicular through c_1 and horizontal through c_4, will be a point on the converted high-pressure diagram corresponding with c_2. In the same way lay off $P_1a_3 = aa_2$, drop the perpendicular a_3a_4; then a_5, which is the point of intersection of the perpendicular through a_1 and the horizontal through a_4 will locate the point corresponding to a_2. By locating a sufficient number of points they can be connected into a compiete diagram of the high-pressure cylinder converted to the same scales of volume and pressure as the low-pressure diagram.

A new slant on things observed in and out of the power plant

What Happens and Why?

An Ingenious Belt-Tension Dynamometer

IT WOULD be hard to find a neater illustration of the relations of belt tensions and speed to power delivered than is furnished by the apparatus shown in Fig 1. This is a photograph of a dynamometer used by a manufacturer of ammonia compressors to measure the power required to drive them.

This apparatus makes use of the principle that the work delivered to a machine by a belt is the product of the distance the belt travels by the difference between the belt tensions on the tight and loose sides. A special layout of pulleys permits direct measurement of the difference in tension.

Reference to Fig. 2 will make the arrangement clearer. Between the motor driving pulley A and the compressor driven pulley B is a series of idler pulleys C, D, F and G. The floating idler C takes the slack out of the loose side of the belt, while D guides it to and from the frame E at the proper angles, with the aid of the idlers F and G. The frame E is so held by toggles as to be free to move up and down. As idlers do not alter belt tension, the entire top of the belt has the low slack-side tension T_2 and the entire bottom side the higher tight-side tension T_1. The difference $T_1 - T_2$ is the net effective pull on the rims of A and B. Multiplied by the belt speed in feet per minute, this gives the power in foot-pounds per minute, which has only to be divided by 33,000 to give the horsepower.

The belt angles are so laid out that if the dead weight or tare of E is allowed for, the scale reads $T_1 - T_2$ directly. This is made evident by a study of Fig. 3. The force triangles are laid out by placing the force arrows end on end without changing their directions. A line drawn from the beginning of the first to the end of the last gives the resultant or net effect of the forces. The 30-deg. incline of the belt approaching and leaving the idlers makes these triangles equilateral, so that the upward resultant B is equal to T_2 and downward resultant A is equal to T_1. The net effect of these two resultants is a downward force equal to $T_1 - T_2$. The horsepower can then be figured by the formula, horsepower = net scale reading × belt speed in ft. per min. ÷ 33,000.

Another photograph of this dynamometer appears on page 524.

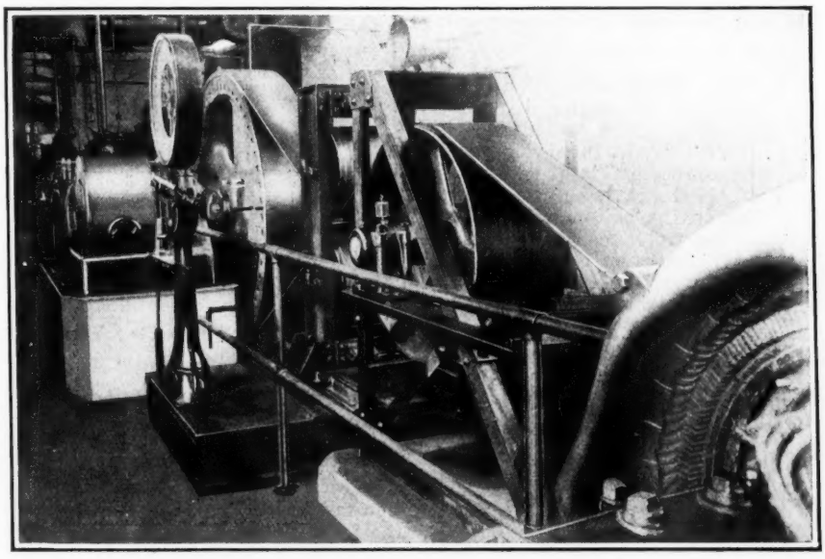


Fig. 1—Dynamometer measures power delivered to compressor by motor

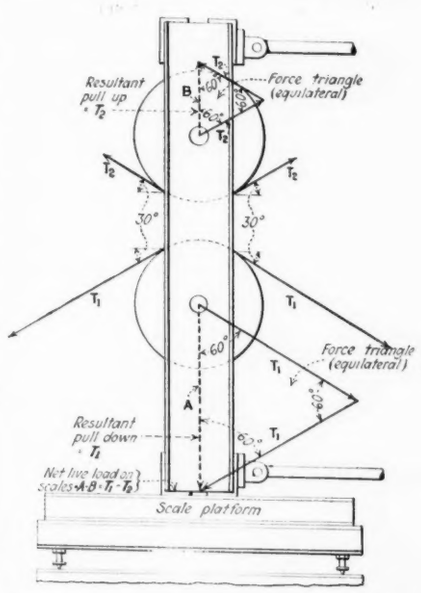


Fig. 3—Resolution of forces shows that net load on scales equals $T_1 - T_2$

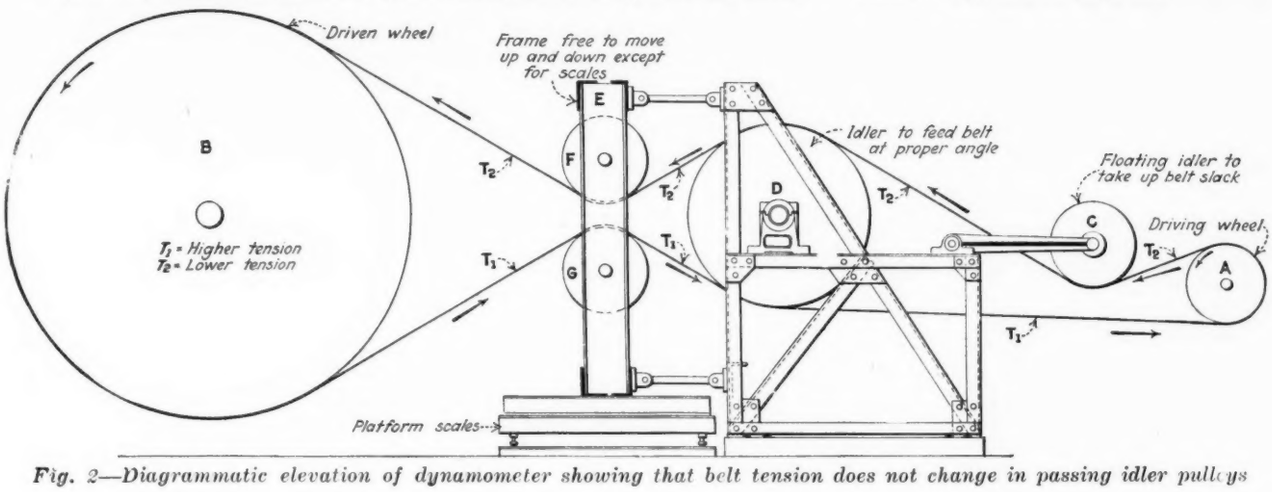


Fig. 2—Diagrammatic elevation of dynamometer showing that belt tension does not change in passing idler pulleys

New and Improved Equipment

E. Keeler Co. Builds New Type Boiler

By reason of the small space available for the heating plant, architects often specify low-pressure boilers for office and apartment buildings. These boilers cannot be converted at a later date into power boilers by reason of their lighter construction. The E. Keeler Co., Williamsport, Pa., has brought out a boiler which, while built for high pressure, requires no more floor space than does the usual heating boiler; by reason of its design the installation costs are but little greater.

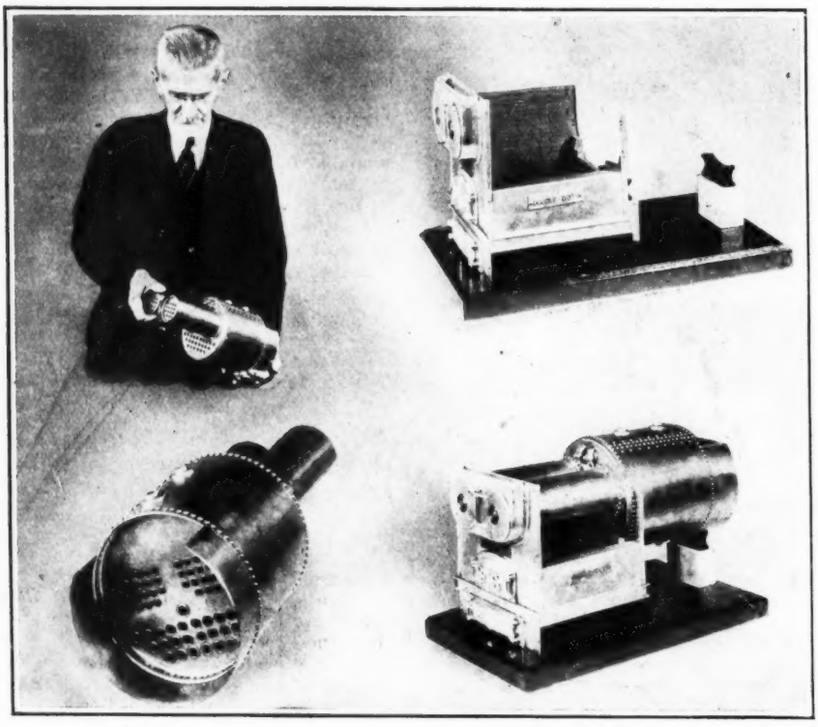
The boiler is constructed of one large-diameter barrel or shell to which are riveted two smaller shells or drums, as will be seen from the illustration of a model of this boiler. Passing from the front head of the small drums into the rear head of the larger shell is a bank of 3-in. tubes placed in vertical rows. Beneath these tubes and extending from head to head in the larger shell is a bank of 4-in. tubes.

The two small drums that form the top of the boiler furnace are at such a height above the grates that there is ample room for complete combustion. The gases of combustion pass through the 4-in. tubes into the brick-lined rear chamber of the large shell. Here they are deflected upward and forward through the bank of 3-in. tubes to the front of the boiler, then through the front smokeboxes into the breeching or stack.

The rear combustion chamber is formed by extending the large shell. It is provided with cast-iron doors-covering the three tube banks, and is arranged for firebrick lining. The front smokeboxes are formed by extending the small drum shells, the tops being cut out and provided with saddles for a single smoke connection. The furnace is formed of a steel casing, amply reinforced with channel iron and angle iron. It is arranged for a 9-in. lining of firebrick.

The manhole opening, located in the large shell between and above drum connections, is reinforced with a heavy band shrunk on, doweled in place, and machined to form a seat for the manhole plate. The handhole openings, one in the front head of each drum under the tubes and one in the bottom of the large shell, are of standard construction and provided with self-centering steel plates, with suitable yoke and gasket.

The main steam connection is the same in design, material and thickness as that used for high pressures, being a forged steel nozzle, faced and drilled. The feed connection is placed in the front of the large shell, the blowoff connection in the bottom of the large shell, and the water-column connections arranged in the drum heads and small shell, so the water column may be placed either right or left hand.



Model of double-duty steam boiler

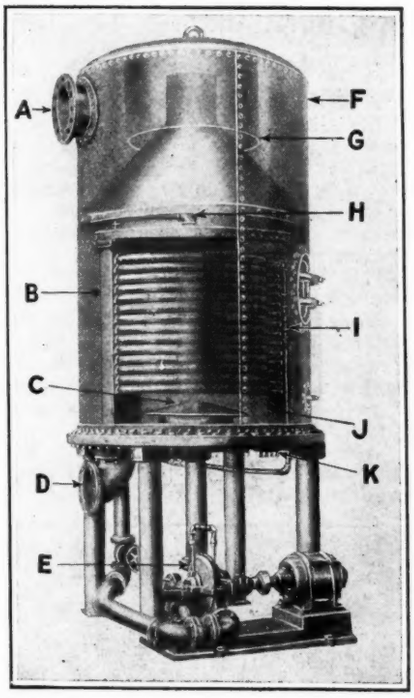


Fig. 1—Evaporator assembly

A, vapor outlet; *B*, steam header; *C*, sediment baffle; *D*, steam inlet; *E*, re circulating pump; *F*, vapor dome; *G*, separator; *H*, distributing nozzle; *I*, air vent pipe; *J*, drain header; *K*, drain outlet.

Wheeler Film-Type Evaporator

The illustrations show a film-type evaporator brought out by the Wheeler Condenser and Engineering Co., Carteret, N. J. In operation the water is showered over the tubes and evaporation takes place without ebullition from the falling film of liquid. The surplus water collects in the bottom of the evaporator and is re-circulated by means of a centrifugal pump. The feed water is introduced on the suction side of the re-circulating pump, and the blowoff is taken from the discharge side.

The tubes are of an elliptical cross-section and are bent to the shape shown in Fig. 2. Instead of ending in a dead end at the center the tube bends back upon itself and is brought out to a vent header opposite the steam header. Changes in the relative pressure of the steam within the tubes produce considerable motion, which tends to crack off adhering scale. The tubes are connected at both ends to vertical headers. To one of these live steam is supplied, and from the other the non-condensable gases are vented. Drips are removed from both headers.

The shell of the evaporator is a vertical cylinder containing an integral vapor separator. On disconnecting the vapor pipe the entire shell may be re-

moved from the base, as the steam headers, re-circulating pipe and vent pipe all enter the evaporator through the base. A sediment baffle is provided to prevent dislodged scale from getting into the suction of the circulating pump. Handholes are provided in the shell for the removal of scale and mud from the bottom of the evaporator.

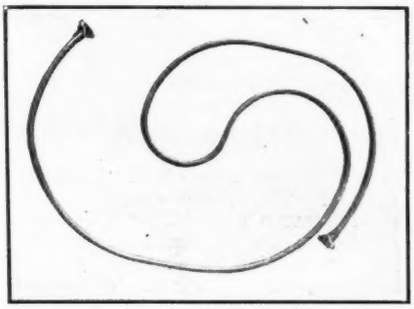


Fig. 2—Tubes are elliptical and connect to a header at each end

Pennsylvania Armor-plate Coal Crusher

The Pennsylvania Crusher Co., Philadelphia, has recently extended its line of single-roll armor-plate crushers by the addition of much larger units than heretofore made.

The new units are being built in sizes from 18 diameter roll and 24 in. wide to 30 diameter roll and 72 in. wide, giving capacities from 30 to 500 tons of coal an hour. With the exception of the breaker plate and roll segments they are entirely of steel construction, 30-in. I-beam girders being used for the side-frame construction, as shown in Fig. 1. Cross-members of heavy channel and angle plates are hot-riveted to the girder-beam side frames. Steel bearing housings shouldered into the side frames to take the shear and hot-riveted in position are fitted with interchangeable die-cast bearing bushings. Lubrication of the bearings is accomplished by large grease cups piped to convenient locations on the crusher frame.

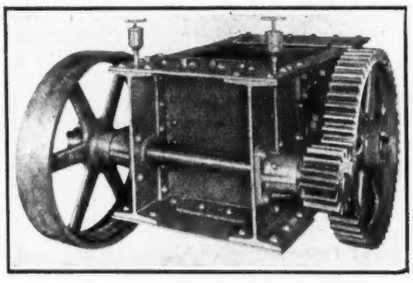


Fig. 1—General view of crusher

The crushing roll is of special segmental construction, having no bolts through the crushing surface. The segments are held in place by tapered steel dowels and one through bolt. The breaker plate tip, which takes the major portion of the wear in the crusher, is of manganese steel and is renewable. The plate is readily adjustable for varying the fineness of crushing.

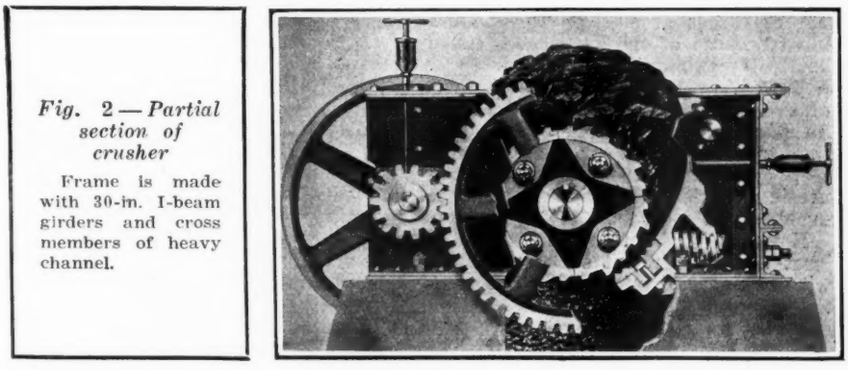


Fig. 2 — Partial section of crusher

Frame is made with 30-in. I-beam girders and cross members of heavy channel.

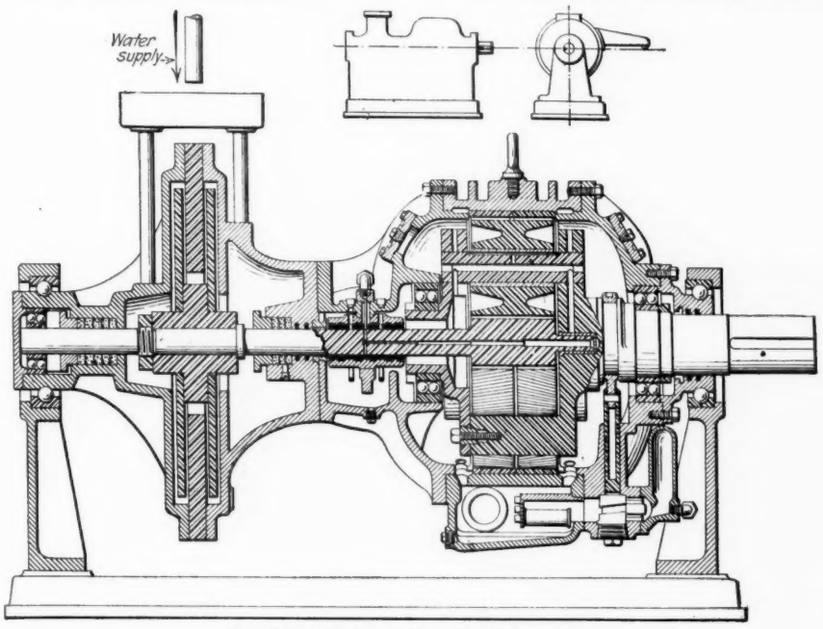
A New Absorption Dynamometer

Patents covering an absorption dynamometer of a geared type have been applied for by J. Y. Dahlstrand, assignor to the Standard Turbine Corp., Scio, New York.

While the broadest claims specify any type of a gear and any type of absorptions means, the brake built by the company is substantially the same as illustrated herewith.

The brake itself consists of smooth disks revolving in water, the surface exposed to water being regulated by means of admission and discharge of water from the brake chamber. The gear is of the planetary type, preferably double helical construction.

The low-speed gear shaft is attached to the engine, and the pinion shaft is integral with the dynamometer shaft. Through this construction it is possible to benefit from high rotative speed of the pinion with resulting high absorption capacity of the disks and still the gear shaft can revolve at a relatively low speed.



Section of absorption dynamometer

The absorption capacity of a brake of this type varies nearly as the 2.8 power of the operating speed, so that while a brake operating at, say, 500 r.p.m. would absorb 1 hp., the same brake operating at 3,000 r.p.m. would absorb about 151 hp. From this it is evident that while a brake, to test oil engines or low-speed steam engines, of the smooth disk type direct-connected, will be impractical on account of the tremendous size for even relatively low horsepowers, it becomes practical when geared.

The manufacturers claim for this brake the following advantages: All losses such as bearing losses, gear losses, windage friction, etc., will be recorded on the scale beam of the brake so that no corrections whatever need be made. Smooth operation at all speeds. Great range in absorption since by varying the water level the whole range of the brake can be utilized. Furthermore, water may be entirely shut off from some compartments for low loads, allowing air to circulate past the disks to cool them. Small size and low weight for a given absorption capacity. The brake is reversible and will operate equally well with either direction of rotation and is totally enclosed. On account of the flywheel effect of the disks the brake will have a steadying influence on the engine. The brake has a complete oiling system, oil being circulated by means of a pump to the gears and all bearings.

Factors Bearing on the Design of Large Turbines*

By FRANCIS HODGKINSON
Chief Engineer of the South Philadelphia Works, Westinghouse Electric & Manufacturing Company

THE first multi-cylinder or compound turbine was a tandem-compound introduced by Parsons in 1899, being of 1,000-kw. capacity. At the present time the most notable installation represents the three large multi-cylinder units at the Crawford Avenue station of the Commonwealth Edison Co., Chicago. It appears that the tendency now is to abandon the practice of operating the elements of the cross-compound turbine individually, and instead, to regard the entire turbine, including all cylinders, as a single unit.

Since the limit of capacity for any given rotative speed is the amount of area of the exhaust row of blades, which is restricted by the physical qualities of the blading, it appears that the competition for developing the largest capacity unit has been well described as a race of manufacturers to secure the greatest leaving areas at given rates of speed.

Low Speed Gives Greater Unit Capacity

In comparing the design factors of the last blade rows the various turbines are reduced to an equivalent geometrically similar turbine of the same peripheral speed at 1,800 r.p.m. This would also have the same leaving loss, centrifugal stresses and relation of critical speed to running speed as the original. The blade areas, and consequently steam flow and capacity, will vary inversely as the square of the rotative speed. This would seem to be the best method of bringing turbines of different speeds to a common basis of comparison.

It would seem evident from the tabulated comparisons that higher qualities of design could be secured by lower rotative speeds of low-pressure elements than is the general practice, which is true enough so long as the blade dimensions are large enough to render leakage an unimportant factor in this portion of the turbine.

Weight per Kilowatt Increases with Lowered Speed

A disadvantage of reduced rotative speed, however, in the low-pressure element is that it involves greater weight for equal capacity. The maximum power that can be secured at a given speed represents the most desirable machine from the viewpoints of both purchaser and manufacturer, since it requires the least weight per unit of power.

For similar turbines the weight per horsepower or per kilowatt varies inversely as the speed, assuming the same stresses. Generally speaking, if the speed is doubled the weight per unit of power is cut in half, provided the machines are similar geometrically throughout.

Smaller diameters and other dimensions will be necessarily in proportion, so as to secure the same unit stresses. The weight will thus be reduced to one-eighth of the original, varying as the cube of one dimension and the power cut to one-quarter of the original. The weight per kilowatt is thus halved when the speed is doubled.

This is the reason why the maximum capacity that can be secured at a given speed is always the most commercial machine from the viewpoints of both manufacturer and purchaser, so that engineers will strive, as in the past, to increase blade dimensions and the velocities of the last row, employing the highest possible rotative speeds.

Large Capacity Gives Better High-Pressure Element Efficiency

The greater the capacity of a turbine at a given rotative speed, the easier becomes the problem at the high-pressure end because of the greater relative steam volumes. The difficulty in the past with any type of turbine has been to secure efficient high-pressure elements to deal with such small volumes.

The reaction type of element, while possessing the highest inherent efficiency, suffers the disability of high leakage loss unless the steam volumes are relatively large. With the impulse type, however, leakage occurs only where the relatively small diameter shaft passes through the diaphragm. It has the further disability that a greater number of rows of reaction blading is required than the number of stages in an impulse turbine for the same blade speed and heat drop.

Shortest Axial Length per Stage in Large Impulse Turbine

On the other hand, the impulse type departs from the simplicity of the reaction type because of intercellular construction, involving a shaft of relatively small diameter with disks pressed thereon, which tends to limit the number of stages in a given turbine element because of the lesser stiffness of shaft if maximum advantage is to be taken of low leakage. A stiffer shaft of greater diameter would mean more interstage leakage. For this reason the stages are made to occupy small axial space and present a difficult engineering problem of design in order to avoid lateral vibrations of the disks.

However, any turbine may have at least its first element of impulse type without the mechanical difficulties mentioned, and be free from leakage, changing to the reaction type in the low-pressure zones. The point of change and the employment of either single- or multiple-velocity impulse elements depends upon the steam volume involved.

This is less true of two-speed compounds. The higher-rotative speed, high-pressure element permits greater relative areas of blades, thus allowing the reaction elements to be advantageously carried into the higher zones of pressure.

Investigating Effect of Temperature on Blade Vibration

The natural frequency of blade structure is proportional to the square root of the modulus of elasticity, and later research indicates that the elastic modulus is a variable quantity, depending upon temperature, stress and rate of application of stress. The stress due to centrifugal force is, of course, constant. The stress incidental to the vibration is applied at a variable rate depending upon the frequency and amplitude of the vibration.

An important program of research is being carried out by the Westinghouse company which will determine, First, the effect on the elastic modulus of temperature and stress for the various materials involved. Secondly, the maximum degree of resistance to vibratory stress that can be secured by various forms of lashings for the different standard blades is to be investigated with as rapid heating and cooling as can be produced by the extremes of temperature ever likely to obtain in practice. Thirdly, the natural frequencies of these blade groups will be determined and corrected to the condition of stress and temperature incidental to their operating conditions.

Large Turbine Efficiencies May Be Exceeded

It is well known that the steam turbine of large size, under reasonably favorable conditions, has reached a high degree of efficiency. Eighty per cent or more of what is theoretically possible from the expansion of the steam, is today available at the shaft of the turbine. The turbine designer appears by no means to have reached the end of his tether, however, and there remains much that may be done.

Certainly, greater reliability must be secured and there still remains a modicum of attainment in efficiency. The percentage is small, it is true, but remember that in a base-load station of, say, 100,000 kw. capacity with 75 per cent load factor, a 1 per cent real gain in steam consumption (not necessarily that in a contract warranty) represents a capitalization for fuel alone of $175,000, based on a 15-year life, 6 per cent interest, and $4.50 per ton cost of fuel.

That refers to the prime mover alone, but I think it is still true, though to a less degree than formerly, that it is not the efficiency of the prime mover that

*Abstract of a paper on "Large Steam Turbines," presented at the Chicago Section of the American Society of Mechanical Engineers, Jan. 14, 1925.

spells low cost of power. Highly efficient prime movers contribute little as compared with eternal vigilance in connection with boiler-house problems and matters of heat balance, feed heating, etc., in which subjects, however, great progress has been made of late.

Design Problem Simplified in Two-Speed Compound Turbine

The large-capacity, high-speed turbine-generator of today is no small problem of design, and it may be greatly relieved by the two-speed compound turbine principle. In the case of single-speed turbines (tandem-compound or single-cylinder) there seems to be a tendency in Europe, which possibly should be followed here, of purchaser and manufacturer alike concentrating on and employing the maximum capacity turbine at each of the available synchronous speeds, their best machines being built only in a limited number of sizes.

Machines where high capacity is secured at the expense of increased terminal loss are not here considered, but only machines with design constants based on appropriate leaving losses, velocities of elements and vane-to-steam velocity ratios. At any given speed it is the least costly per kilowatt if similar design constants are employed, unless great cost is incurred in materials and construction for the purpose of securing a high rotative speed difficult of attainment. It is, therefore, the machine on which most money can be spent in the minor details that tends to reliability and efficiency.

The production of cheap power is not dependent on the turbine alone. There is a further possible improvement in the use of higher steam pressures. The gain due to bleeding the turbine for heating the feed water increases with the higher pressures. With three stages of heating it is approximately from 5½ per cent at 300 lb. to 7 per cent at 1,100 lb.

Multi-Cylinder Turbines for Extra-High Pressures

Extra-high steam pressures render the compounding of turbines more than ever desirable because of the greater heat drop. None of us know much about the use of high pressures. We have fair knowledge of the efficiency of turbines designed to operate with moderately high pressures up to 1,200 lb. but know little of the mechanical behavior of the steam in the turbine.

It is not certain that this high-density steam will not be quite erosive. At all events some turbines in Europe that have operated with 450-lb. steam have experienced quite serious deterioration of the high-pressure portion. It happens, however, that the steam in this instance is dirty and carries considerable foreign matter. Whether the difficulty is entirely attributable to this fact is not certain. Be this as it may, it is another suggestion pointing to the desirability of high-pressure elements of low velocity for such applications. More will be known of this shortly.

Reaction Turbines Discussed by Operating Men

In the discussion that followed, Mr. Clark of Sargent & Lundy advised that in about 1900 reheating was arranged for in a machine of approximately 8,000 kw. capacity. Before the plans were accomplished it was decided to make a change in the turbine which was supported as giving the benefit that reheating otherwise would have done. Unfortunately, the innovation did not work out as expected, and the whole thing was a failure. The reheating equipment was not put in, although the foundation was laid for it. If the machine had been originally installed as designed, probably something would have come of it.

Mr. Heaton said with regard to "end-tightening" that, after several experiences with very severe vibration with such a type of Parsons turbine, due to factors entirely disconnected with the matter in hand, in no instance was experienced the slightest trouble due to radial contact of the rotating parts. Those vibrations were of a magnitude that without end tightening would have been probably disastrous to an ordinary type of reaction machine, so that the principle of end tightening was favored.

Design of Piping to Avoid Stresses on Cylinder

In the earlier stages there were troubles due to deflections of the casings, caused by the piping strains. In the recent Crawford Avenue machines the Westinghouse, General Electric and Parsons machines are all worked out in that the pipe connections start at fixed base, coming around with two pipes to the casing, thereby producing no strains whatever. Thus, several small very flexible pipes connect the cylinder to a rigidly mounted structure which in turn is piped to the main header.

In the three turbines purchased for the Crawford Avenue station people may have wondered, Why not buy all Westinghouse? It was desired to find out the very best and most reliable type of machine. There will probably not be much difference. All causes of trouble have been minor, little things that don't look like much until getting into action, the next thing being a "spill." The desire for more rigid and simple turbines is heartily subscribed to.

A New Base Exchanging Silicate for Water Softening

"Base-exchange silicates" or "zeolites," both natural and artificial, have been on the market for some years as water-softening materials. These are complex compounds containing sodium, which they readily exchange for the calcium and magnesium of the "hardness." That is to say, when a zeolite (or a base-exchange silicate) in proper condition is brought in contact with water containing calcium sulphate, the calcium passes into the zeolite, replacing a certain amount of sodium which comes out and unites with the sulphate radical forming sodium sulphate. In the same way calcium carbonate in contact with a zeolite is turned into sodium carbonate. As all the sodium compounds are extremely soluble. these zeolites are available for water softening except under certain special conditions where their operation would not be satisfactory for one reason or another.

It is evident that with the replacement of the sodium by calcium or magnesium the zeolite gradually uses up its power of softening water. This, however, can be regenerated by exposing the zeolite to a common salt solution, whereupon the process takes place in the reverse direction, the sodium from the brine passing into the zeolite and the magnesium and calcium coming out and combining with the chlorine of the brine to form sodium chloride. This, then, can be washed away, leaving the zeolite ready for further use.

While similar in this general way, the various zeolites differ in their weight per cubic foot, in the amount of hardness they can remove, the speed in which they can remove it, time required for regeneration, etc.

At the recent meeting of the American Institute of Chemical Engineers in Pittsburgh, James G. Vail, vice-president of the American Doucil Company, described some of the properties of a new base-exchange silicate called "Doucil." This is distinguished from other exchange silicates by its structure. It is a gel, which is to say that it is a fine cellular body having pores of submicroscopic dimensions, evidently arranged with considerable uniformity and capable of strong capillary action. It is prepared by the complete gelation of a solution made from sodium silicate and sodium aluminate under such conditions of control that its properties are definite and reproducible.

According to Mr. Vail a cubic foot of Doucil contains 25-pounds of anhydrous silicate capable, under practical working conditions, of absorbing 12,500 grains of calcium carbonate equivalent. That is to say, a cubic foot of Doucil will soften 1,250 gal. of 10-grain water in comparison with 270 gal. of the same water for a like volume of "greensand." The molecular composition of Doucil may be approximated by the following formula, $Na_2O.Al_2O_3.5SiO_2$. As with other base exchange silicates, the presence of a large amount of salt or sodium chloride in the water supresses its action. Likewise Doucil is unsuited to treat waters high in hydrogen sulphide or water containing oil.

Doucil is a colorless, translucent substance. Its grains are angular in contour and remind one of pieces of opalescent glass. Mr. Vail states that Doucil is less affected than other exchange silicates by dilute solutions of mineral acid. The entire regenerating operation, according to Mr. Vail, can be accomplished in 30 minutes.

New Power Project for Lake Keuka Announced

Plans for an electric-power project between Lakes Keuka and Lamoka, involving the erection of a dam at Bradford, N. Y., and the construction of a power house at Lake Keuka to develop 25,000 to 40,000 hp., has been announced by officers of the Lamoka Electric Power Corp., with offices at Corning, N. Y. The project will cost nearly $5,000,000, it is said.

Waste-Heat Utilization*

By Prof. Ernst Blau, Vienna

IN CERTAIN cases the heat in the flue gases from processes can be used directly for the preliminary or complete drying of wood. By this means the temperature of the exit gases has been brought to as low as 140 deg. F. But utilization of the heat of the gases from blast furnaces, ceramic and glass ovens and furnaces, gasworks retorts and boiler plants has generally been indirect and is accomplished by simple, effective and inexpensive equipment.

The waste gases may be used for heating feed water as shown in Fig. 1, where three banks of tubes are so arranged in a special brick setting that the gases must pass in narrow streams between the tubes. A unit requiring ten square feet of floor space has heating surfaces of about 100 sq.ft. The absorption of heat is uniformly distributed, and the gas temperature does not drop low enough to cause condensation or sweating which would corrode the tubes. The tubes are heavily galvanized, inside and outside, to increase their life. Provision is made for cleaning the tubes without removing the brickwork. The Petersen waste-heat boiler (Fig. 2) consists of a vertical drum connecting at the top with a horizontal drum. The two drums are also connected directly by a number of water tubes. By suitable baffling the

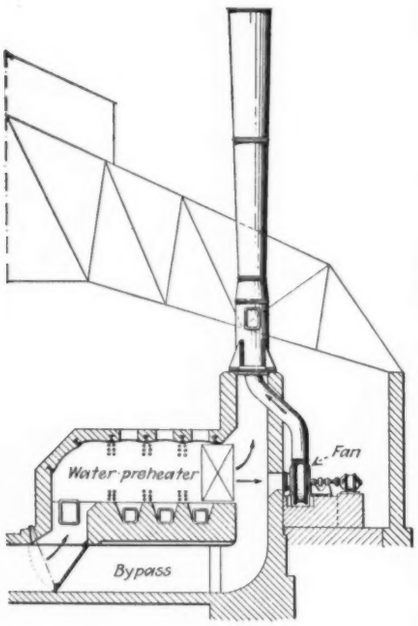


Fig. 1—Apparatus uses waste gases to preheat water

gases may be made to pass along the tubes or at right angles to them. The comparatively large water content of this boiler gives a considerable heat-storage capacity. This is important, for waste-heat boilers, unlike direct-heat boilers, cannot take care of increased loads by increasing the rate of firing. Scale and slime dropped to the bottom of the vertical drums do not affect the tubes. In recent years low-pressure boilers of this type have been perfected to such a point as to make them useful as direct high-pressure boilers where the load is not great. Such boilers are especially useful where steam is required for heating or boiling purposes, as in these cases it is the heat content of the steam that is important rather than the pressure at which it is delivered. Because of the low pressure there is a larger temperature difference between the gas and the heated water, with better resultant efficiency of heat transfer.

In such plants as breweries and sugar refineries warm feed water is

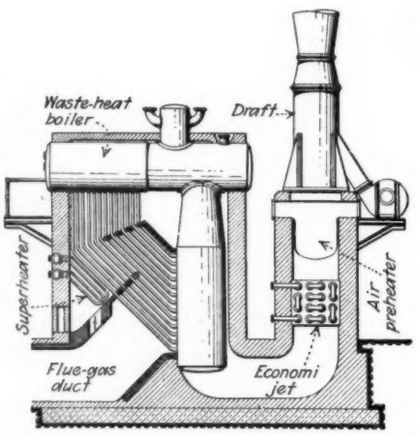


Fig. 2—The Petersen waste-heat boiler

available. There the flue gases may be used to preheat air for heating, drying and similar purposes or to preheat combustion air.

Waste heat may be used for drying purposes in driers of the tower type. The product to be dried is fed automatically along a spiral conveyor, and after exposure to the heating medium, flue gas or warm air, for a period which is controlled by regulating the speed of the conveyor, it is discharged dry. For coarse products a multiple-stage drier may be used in which the product slides from one shelf to the one below by automatic tilting.

Waste heat may be used to produce steam for gas generation. Water gas is produced by blowing a mixture of steam and air through the grate of a shaft furnace. The production of steam by direct-fired boiler is very costly for such use. By having a suitable heat interchanger here, the hot gases produced in the shaft furnace preheat the incoming air. This preheated incoming air is used to atomize and convert into steam the water which has previously been heated as high as possible by waste heat.

Waste gases may be used to preheat feed water and air at the same time. The air is first preheated by the gases in a heat interchanger. This preheated air is further heated by hot water from the boiler under pressure, say at 340 deg. F. The air heated in this manner has not been in direct contact with

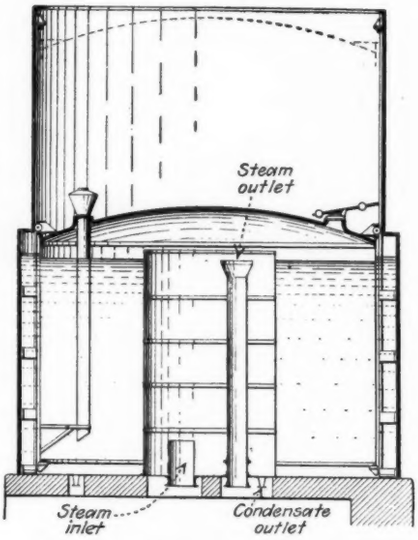


Fig. 3—"Gas holder" for storage of steam at low pressure

either the gas or the boiler water and is sufficiently clean for heating rooms or buildings.

Preventing Air Bubbles from Pitting Condenser Tubes

The fact that local heating due to the presence of an air bubble on a condenser tube or boiler tube may have an important bearing on pitting, was brought out by Dr. Carl Benedicks in a lecture given before the American Institute of Mining and Metallurgical Engineers, Feb. 16 to 19, 1925.

Under these air bubbles corrosion proceeds with comparatively great rapidity, as a result of moist air that is overheated by the insulating action of the air bubble, and the heat received through the condenser or boiler tubes.

The lecturer gave a general statement of this so-called "hot-wall effect" and described experiments by which deep pits were produced under air bubbles which attached themselves to thin nichrome ribbon heated by a current of electricity while immersed in water saturated with air.

A suggested solution of this difficulty is to deaerate the circulating water. The lecturer has evolved a process with this end in view. Electrically heated coils of resistance wire are placed in the supply pipes, and air thus removed by contact with the hot wires, is collected in suitable domes and then removed.

The subject of air bubbles as a cause of condenser tube corrosion was exhaustively investigated, as described in the seventh report of the Corrosion Research Committee of the Institute of Metals, by Guy B. Bengough and R. May, Sept. 8, 1924, in London. This paper was abstracted in the Dec. 16, 1924 issue of *Power*.

*Abstract of paper in Helios. Translation made by Albert P. Sachs, Technical Director, Universal Trade Press Syndicate.

Personnel of President's Muscle Shoals Board

John C. McKenzie, a former member of Congress from Illinois, will head the President's commission which is "to examine into and report to him upon the most practical method or methods of utilizing to the best advantage the Muscle Shoals facilities." The other members selected by the President to serve on the commission are: Nathaniel B. Dial, formerly a Senator from South Carolina; Prof. Harry A. Curtis, of Yale University; William McClellan, of New York, and Russell F. Bower, of the American Farm Bureau Federation.

Chairman McKenzie represented the thirteenth Illinois district in the House of Representatives from March 4, 1919 to March 4, 1925.

Senator Dial who was defeated in the last election, is a man of means and through his cotton mill holdings is familiar with the power situation in the Southeast.

Mr. Curtis is professor of Chemical Engineering at Yale University. He was consultant to the Department of Agriculture in the reorganization of its fertilizer work and was at one time executive officer of the Nitrogen Research Office under the United States Army. He directed the recent world nitrogen survey of the Department of Commerce.

Mr. McClellan, an electrical engineer, is a graduate of the University of Pennsylvania, and was at one time Dean of the Wharton School at that University. He is past-president of the American Institute of Electrical Engineers and has had large experience in construction and operation of electrical equipment.

Mr. Bower has been engaged for some time with the American Farm Bureau Federation in the study of Muscle Shoals problems, particularly in their relationship to agriculture.

Sight is not being lost of the fact that the report is to be made to the President and not to Congress, and may be withheld.

With $120,000 available for the commission's use, it is expected that the essential information necessary to an intelligent decision will be arrayed in more systematic and more complete form than ever before.

New York Increases Boiler Inspectors' Salaries

The New York Senate passed, on March 26, and sent to the Governor, the Hackenburg bill, which amended the labor law by adding a new section 18-b, relating to salaries and grades of boiler inspectors, which is briefly as follows:

The inspectors shall be divided into six grades. Inspectors of the first grade shall each receive an annual salary of $1.680; inspectors of the second grade, $1,800; inspectors of the third grade, $1,920; inspectors of the fourth grade, $2,100; inspectors of the fifth grade, $2,220; inspectors of the sixth grade, $2,400. The chief boiler inspector is to receive an annual salary of $3,500.

Inspectors are to be advanced to a higher grade each year, until the sixth is reached.

The act is to take effect July 1, 1925.

British Government To Aid Low Carbonization

That the British coal trade's future lies in the development of the low carbonization process was the opinion expressed by Col. Lane-Fox, Government Secretary for Mines, in the House of Commons, March 27. By this process it is expected that not only will the smoke be abated, but heavy oil and other valuable byproducts will be produced.

"I have the authority to state," Colonel Lane-Fox, announced, "that the government is going to spare no money, energy or effort to bring this process to perfection. It is our only hope."

Sir Robert Horne took a similar view. "Some of the best scientific brains in the country," he said, "are being applied to this problem, but many people have lost fortunes in low-temperature distillation. When success is reached, it will bring one of the greatest benefits this country has ever secured."

Tentative Program of the A. S. M. E. Spring Meeting Milwaukee, May 18-21

Papers of Interest in Power Plant Field

Monday morning — Council meeting.

Monday afternoon — Business meeting of society; meeting of A. S. M. E. Council; Boiler Code public hearing; excursions to Sewage Disposal Plant, Palmolive Co., Phœnix Hosiery Co.

Monday evening—Reception.

Tuesday morning—"A Microscopic Study of Pulverized Coal," by L. V. Andrews; "Radiation in the Pulverized Fuel Furnace," by Walter J. Wohlenberg and Donald G. Morrow; "Boiler Furnaces for Pulverized Coal," by A. G. Christie; "The Parallel Operation of Hydro and Steam Plants," by F. A. Allner; "Mechanical Features Affecting the Reliable and Economical Operation of Hydro-Electric Plants," by E. A. Dow; "Mechanical Problems of Hydraulic Turbine Design," by William M. White.

Tuesday afternoon—Excursions to Allis-Chalmers Manufacturing Co., Kline's Inc. (powdered fuel plant), Robt. A. Johnston Co., Kearney & Trecker Co.

Tuesday evening — Milwaukee Session—"The Activated Sludge Sewage Disposal Plant at Milwaukee," by John A. Wilson; "Critical Study of Heat and Power Requirements of Sewage Disposal Plants," by Robert Cramer; "Duty Tests of Vertical Triple Expansion Pumping Engines, Milwaukee, Wis.," by Charles A. Cahill; "The Economical Advantage of Cities Having Diversified Industries," author to be announced.

Wednesday morning — "Torsional Vibration and Critical Speeds of Shafts," by Dr. Arnold Lack; "Tests of a Uniflow Engine," by G. H. Barrus; "The X-Ray Examination of Steel Castings," by I. E. Moultrop and E. W. Norris; National Defense Session.

Wednesday afternoon—Excursions to Vilter Manufacturing Co., Riverside Pumping Station, Falk Corporation.

Wednesday evening — Dinner and public meeting.

Thursday morning—"A Review of Steam Turbine Development," by Hans Dahlstrand; "National Design of Covering for Pipes Carrying Steam Up to 800 Deg. F.," by W. A. Carter and E. T. Cope; "Analysis of Power Plant Performance Based on the Second Law of Thermodynamics," by W. L. DeBaufre; "Lake Waters for Condensers," by A. G. Christie; "Comparison of Actual Performance and Theoretical Possibilities of the Lakeside Station," by M. K. Drewry.

Thursday afternoon—Excursions to Lakeside Power Station and Nordberg Manufacturing Co.; Joint Session with the American Society of Refrigerating Engineers — A Public Hearing on Joint Test Code for Refrigerating Apparatus and Plant.

Susquehanna River Conowingo Project Meeting Obstacles

Merrill States Difficulties Encountered—Philadelphia Rapid Transit Seeking Control of Philadelphia Electric

FOR Maryland to reserve the right to recall power exported from the state in connection with the proposed development at Conowingo on the Susquehanna River probably would have the effect of preventing the development of the project by those now proposing to undertake it, in the opinion of O. C. Merrill, the Executive Secretary of the Federal Power Commission.

"The Conowingo project," Mr. Merrill says, "is one that can be built economically only if it is to develop a far greater proportion of secondary power than is customary. It is proposed to make an initial installation of 280,000 hp., although the primary power is less than 50,000 hp. Such a large proportion of secondary power can be used only in a market that has steam capacity at least equal to this secondary power. Steam and hydro installations must be adjusted so as to supplement each other. If those who propose to develop the project must look forward to losing all of the primary power—for that is the only power that would be suitable for withdrawal for independent service in Maryland—it is doubtful if the project would be worth developing. If the Maryland corporations concerned in the development are required to render service in the territory where they now have charter rights, that is all, in my opinion, they could afford to do without jeopardizing the undertaking.

"I assume that the State of Maryland has authority to fix the contract price between a wholesaling company and a distributing company if both are corporations of the state. I assume also that Maryland has authority to regulate the rates and services of the distributing company. As to its authority to fix the contract price when power is wholesaled to a domestic distributing company by a foreign corporation from sources outside the state, I have grave doubts. Such a situation exists in the purchase of power by a Baltimore distributing company from the Holtwood project in Pennsylvania. I know of no cases where these questions with respect to interstate power transmission have been decided definitely, but analogous cases of interstate wholesaling of natural gas cast considerable doubt on the exercise of such power by the states.

"It happens in the Conowingo case that the companies were required to take out a federal license. One of the conditions imposed as a prerequisite to approval was that the proposed contract should be revised so as to provide specifically that the contract rate is to be subject to revision, either by the State of Pennsylvania, the State of Maryland, or the Federal Commission, whichever may be found to have jurisdiction over the interstate sale."

According to newspaper reports, E. T. Stotesbury, of Drexel & Co., told the Pennsylvania Public Service Commission at a hearing on March 27, on the $52,000,000 project that his concern's fee for financing the proposition was to be $1,170,000 and in addition Drexel & Co. would receive whatever commissions market conditions warrant when the proposed $38,000,000 bond issue is floated.

At a previous hearing Ellis Ames Ballard, attorney for the Philadelphia Rapid Transit, alleged the banking profits from the construction of the Conowingo dam would reach $5,000,000 or more. Mr. Ballard questioned Mr. Stotesbury after his statement.

The fee, the banker said, amounts to less than 2 per cent of the total cost of the project, which he declared was considered by the bankers fair compensation for abandoning their rights to develop the water-power plan themselves. The Philadelphia Rapid Transit estimates the ultimate cost of the project at $90,000,000.

Conowingo Project Declared Uneconomic

The Philadelphia Rapid Transit Co. has sent out to stockholders of the Philadelphia Electric Co. an assurance of an additional 2 per cent upon the common stock of the Pennsylvania Electric conditional upon receiving sufficient of the new proxies signed by Philadelphia Electric stockholders to enable it to elect directors at the annual meeting which is to be held on April 8. The Philadelphia Rapid Transit Co. states that its sole interest in the Philadelphia Electric lies in preventing the uneconomic Conowingo project being imposed upon the stockholders and customers of Philadelphia Electric and upon the Transit Company's car riders for banker's profits.

Blue River Has Large Power Possibilities

The engineers of the Interior Department have recently mapped Blue River, which is about 70 miles from Denver, in Colorado. As the basin of Blue River is perched so high upon the western slope of the Continental Divide, most of the land will never be irrigated and the river will therefore be chiefly used for power purposes.

The engineers found six power sites between Breckenridge and the mouth of the river which have a capacity with the existing flow of 22,000 hp. for 50 per cent of the time and 12,000 hp. for 90 per cent of the time. The continuous natural flow and consequently the power available can be increased nearly four times by constructing a reservoir having a capacity of 230,000 acre-feet. A site for a dam that would create such a reservoir was discovered and mapped in Green Mountain Canyon. With this reservoir in operation the capacity of the six sites would be 45,000 hp. for 50 per cent of the time and 42,500 hp. for 90 per cent of the time.

A copy of the report showing the power that may be developed has been prepared by E. E. Jones, of the Geological Survey, for use by the Interior Department in Washington, D. C., where it may be consulted. Another copy may be seen at the district office of the Geological Survey in Denver at 403 Federal Bldg.

Trade Association Statistics Status Still Uncertain

The new Attorney General is not expected to take up actively the matter of trade association statistics until the Supreme Court of the United States decides the cement and maple flooring cases. Since these forthcoming opinions may go far toward clearing up the uncertainty that now exists, the plan advocated by industry to bring test suits will not be pressed in the meantime.

Canada Will Conserve Its Electric Power

Charles Stewart, Canadian Minister of the Interior, informed the Canadian House of Commons on March 31, the press reports, that, as far as he could ascertain, there was no intention of issuing export licenses for electric power for a longer period than one year: "I think it is good business to keep this power in Canada for development of Canadian industries, and as one means of retaining this power, I think we are entitled to the export tax."

Bids Will Be Asked for Muscle Shoals Power

The War Department in the near future will advertise for bids for the lease of power at Muscle Shoals pending definite disposition of this power by Congress. In response to a question by the Washington Correspondent of *Power*, Secretary Weeks revealed on March 30 that he would sell all of the available power on a short-time lease which, however, would be revocable at any time on thirty days notice whether the nominal period of the lease would be for six months, a year or eighteen months would be a matter of negotiation, he said. Because of the uncertainty surrounding the action Congress may take, Secretary Weeks expressed the opinion that no company probably would feel justified in incurring any great amount of expense in transmission-line construction to get power on this temporary basis.

Colonel Spaulding, in charge of construction at Muscle Shoals, has been called to Washington to participate in the preparation of the lease.

While the President favors the utilization of the power at Muscle Shoals under temporary leases, he believes it would be wise, in that connection, to consult the commission which he just named. A statement to this effect was made at the White House March 31. The President wants to be absolutely sure that the sale of the power, pending action by Congress, will not interfere with the final disposition of the properties—the losses from failure to realize on the power immediately would be preferable, it was indicated.

Switzerland Completes Four Hydro Stations

Four hydro-electric power stations have recently been completed in Switzerland, and another is under construction, according to articles in the press. These four stations will produce 170,000 hp., which is to be utilized by the electric railroads of the country.

Boiler Manufacturers Should Register in Code States

The Uniform Boiler Law Society has called the attention of the boiler manufacturers to the fact that there has been some misunderstanding between one or two boiler manufacturers and the authorities of one of the code states, due to the fact that the boiler manufacturer had not registered in that particular state. In order that there may be no further misunderstanding, attention is called to the necessity for manufacturers who desire to do business in code states, to register with the individual Boiler Inspection Departments of code states.

Airplane Carrier "Saratoga" Launched April 7

The United States ship, "Saratoga," the first of two airplane carriers, launched April 7, was originally to have been a battle cruiser, but the modification of America's naval program led to its conversion to a carrier.

Beside being a floating airplane field, it will be also a floating electric generating plant. Its power plant will have a capacity of 180,000 hp.; its speed will be more than 33 knots, its length is 874 ft. and its beam 105 ft. The principal use for the power will be the propulsion of the ship. This apparatus will consist of four G.E. 32,200-kw. turbine generators supplying current to eight 22,500-hp. motors. The generators will be operated by steam from 16 oil-fired boilers.

Electrotechnical Commission To Meet at The Hague

The International Electrotechnical Commission, which will meet at The Hague, Holland, from April 16 to 23, will have as representatives from the United States: Dr. C. H. Sharp, president of the U. S. National Committee; Dr. C. O. Mailloux, honorary president of the Electrotechnical Commission and honorary president of the U. S. National Committee; C. E. Skinner, of the Westinghouse Electric & Mfg. Co.; L. L. Elden, Edison Electric Co. of Boston, and representing the N.E.L.A.; S. E. Doane, chief engineer, National Lamp Works, Nela Park, Cleveland, Ohio; E. A. Snyder, General Electric Co., Pittsfield, Mass., and representing the A.S.T.M.; H. S. Osborne, chairman, Standards Committee, and possibly General Salzman, chief signal officer; representatives of the Electric Power Club and the telephone interests.

The program contains sessions of interest to the power-plant field as follows: Rating, standard pressure, transformer oils, prime movers.

The United States National Committee sailed on April 4.

Governor Smith Advocates Tri-State Power Compact

A special message setting forth the need for an understanding among the States of Pennsylvania, New Jersey and New York with respect to regulations for the transmission of electric power by the three states and suggesting the Public Service Commission as the best New York agency for negotiating a compact was sent to the Legislature by Governor Smith on March 27.

"The State of New Jersey, which has neither coal mines nor water power," the message said, "is a potential customer for large quantities of electric power from both the State of New York and the State of Pennsylvania.

"As the development grows, the tendencies of the companies generating and transmitting this electrical power will be to remove themselves as far as possible from local or state regulation on the ground that transmission across state lines makes it a subject of interstate commerce.

"Such development would be disastrous in so far as the state is concerned, as it would place in Washington the regulation of electrical rates and deprive the state of control of its own resources for developing electrical energy. The State of Pennsylvania and the State of New Jersey are aware of this possible development and the danger which accompanies it, and recently the Governors of these states transmitted to their respective Legislatures messages calling attention to the facts and recommending the creation of a commission to confer with their sisters to study the problem and to make recommendations as to the best methods of meeting it.

"There is no question but that the States of Pennsylvania, New Jersey and New York, on account of their geographical relation should come together for their mutual protection and should endeavor by every lawful means within their power to retain to themselves the regulation of these electrical rates and to see that such regulation does not come under the supervision of the federal government.

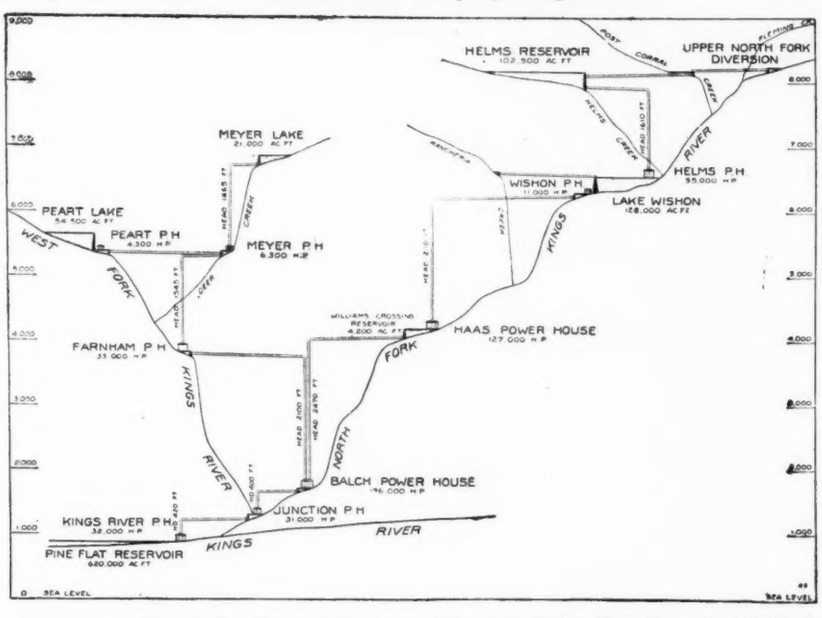
"This result might be accomplished by the entering of these three states into a treaty or compact to provide for the regulation of service and rates for companies operating between these states."

California To Have Highest Head Plant in America

Work will be started immediately by the San Joaquin Light & Power Corp., Fresno, Calif., on the Balch plant of its Kings River development. The initial installation will consist of a stream-flow plant containing a 28,250-kw. generator driven by double-overhung impulse waterwheels. The effective head will be 2,400 ft., making this the highest-head hydro-electric unit on the North American Continent. The work will cost about $5,000,000 and the plant is to be ready for operation by Jan. 1, 1927.

A simple concrete dam will divert the water through a 19,600-ft. 12x12 ft. unlined tunnel. A single penstock, branching at the lower end for the two wheels, will convey the water from a surge chamber to the plant. The penstock will be 4,725 ft. in length, 58 in. in diameter at the top and 26 in. at the bottom. It will be of welded steel 1⅝ in. thick at the lower end and taper down to a thickness of ⅜ in. at the top. Up to a thickness of ¾ in. riveted steel will be used. Transmission will be at 110 kv. a distance of 39 miles to Sanger substation, near Fresno.

Balch power house will ultimately contain six units similar to the first, with a total capacity of 146,000 kw. The Kings River project has 500,000 potential horsepower, which will be developed according to the tentative scheme shown in the accompanying diagrammatic profile drawn by the company's engineers.



Diagrammatic profile, Kings River development of the San Joaquin Light & Power Corp. Total plant capacity 495,000 hp. Total reservoir capacity 310,000 acre feet

Unit System of Pulverized Coal Discussed

The principles and advantages of the unit system of firing pulverized coal and its field of application formed the subject of discussion at a meeting of the Metropolitan Section of the A. S. M. E. on the evening of March 31.

The meeting was opened by Mr. S. H. Libby, chairman of the Metropolitan section, who expressed the welcome of the Society to the large number of student members present. Mr. John H. Lawrence presided as chairman of the meeting.

Dr. Hirsh, of the Furnace Engineering Co., who was the first to speak, reviewed the recent progress that has been made in the development of the Simplex unit-type pulverizer, which had resulted in considerable reduction in the size of the unit for a given output. He said that the unit system had been developed to the point where it was now receiving due consideration in all pulverized fuel projects.

W. W. Pettibone outlined the principles of the Aero unit and reviewed its field of application in relation to that of the storage system. He spoke of one installation in particular where fuel of 8,500 B.t.u. and 25 per cent ash was being burned satisfactorily with the unit system.

H. B. Jones, of the Fuller-Lehigh Co., read a paper dealing with the application of the unit system. In commenting on why there was a unit system he said: "The storage system has thoroughly established itself as a practicable workable method and has produced results of such economic character as to attract attention of engineers responsible for plants of all sizes. To their disappointment some have found that this system cannot be applied to their problem without the investment amounting to a figure which makes it difficult to get the improvement authorized. To place the recognized advantages of pulverized-coal firing within the reach of those who consume relatively small quantities of coal, the unit system has been developed." He stated that where this system has disappointed through failure to meet expectations, the trouble can nearly always be traced to incompetent design of mill, burner or furnace as there are enough of these installations now operating satisfactorily to establish thoroughly the dependability and economy of the unit system in its field. An abstract of this paper will appear in an early issue.

In the light of his experience with both the unit and storage system, H. D. Savage, of the Combustion Engineering Co., expressed the opinion that there was unquestionably a field for the unit system in industrial plants, but that it had not been developed to a point where it would replace the storage system in the large station. He thought that the chief advantage, simplicity, claimed for the unit system was more apparent than real and that the difference in initial cost of the two systems was very little if figured on the same maximum capacity ratings.

Written discussion was presented by J. K. Bloom, of the K. B. Pulverizer Co., and Henry Folz, U. S. Rubber Co.

Combination Power and Heating Plant for Rochester

The Rochester Gas & Electric Co., Rochester, N. Y., is building the first section of a plant designed to supply low-pressure exhaust steam for heating and high-pressure steam for process work. It is expected to put this plant into operation the first of next October. This plant will be located in a rapidly growing business district of the city.

In the initial installation there will be two powdered-coal fired boilers with a capacity of evaporating about 120,000 lb. of water per hour at 375 lb. pressure. There will also be installed a 3,000-kw. non-condensing turbine which will be operated from the middle of September to the middle of April of each year, which is the heating season. Steam will be expanded from a boiler pressure of 375 lb. down to 5 lb. back pressure in the turbine after which it will be reheated to about 30 deg. superheat to evaporate any moisture in the steam, and is then discharged into the heating mains. This turbine, operating on 5 lb. back pressure, will require only about 10 per cent more steam to produce a kilowatt-hour than an old vertical unit installed by the company in 1908 and exhausting against a 28-in. vacuum. The heating steam main will be carried in the same duct with the 100-lb. process steam main.

A. I. E. E. Program for the Spring Convention

THE American Institute of Electrical Engineers, 33 West 39th St., New York City, will have on the program for its spring convention, which is to be held at St. Louis, Mo., from April 13 to 17, papers of interest to *Power* readers as follows:

"Trenton Channel Station," by C. F. Hirshfeld, Detroit Edison Co.

"Cahokia Station," by H. W. Eales and E. H. Tenney, of the Union Electric Light & Power Co.

"Philo Station," by E. H. McFarland, Beach Bottom Power Co.

"Weymouth Station," by I. E. Moultrop, Edison Illuminating Co. of Boston.

"Interconnection of Systems with Frequency Changers," by H. R. Woodrow, Brooklyn Edison Co.

"Initial and Sustained Short-Circuits in Synchronous Machines," by V. Karapetoff, Cornell University.

"Short-Circuit Currents of Synchronous Machines," by R. F. Franklin, General Electric Co.

"A Two-Speed Salient-Pole Synchronous Motor," R. W. Wieseman, General Electric Co.

"Self - Excited Synchronous Motors," by J. Kostko, Palo Alto, Calif.

"Synchronous-Motor Drive for Rubber Mills," by O. W. Drake, Westinghouse Electric & Manufacturing Co.

"Use of Purchased Power in Glass Manufacture," by A. L. Harrington, Pittsburgh Plate Glass Co.

A. S. M. E. Students Debate St. Lawrence Waterway

At the Indianapolis Section meeting of the A.S.M.E., which was held on March 27, the program included, after a dinner, a debate between the Rose Polytechnic Institute and Purdue University students and a talk on the World Power Conference by Calvin W. Rice, secretary of the A.S.M.E.

The question for debate was: "Resolved, That the United States Should Favor the Building of a Great Lakes-St. Lawrence Waterway in Co-operation with Canada."

The affirmative was upheld by F. M. Sloan, G. E. Willers and C. H. Borneman for Purdue. The negative was defended by E. J. Lyons, V. E. Schlossberg and H. E. Dorsey for Rose Polytechnic.

The affirmative issues were that the project is feasible, needed, and economically wise. The negative granted the feasibility of the project, but tried to prove that it was not necessary, not a sound financial investment, and that it would lead to international difficulties.

After spirited argument on both sides, for which the audience expressed appreciation, the judges decided in favor of the Purdue team.

Personal Mention

Prof. Harris J. Ryan, professor of electrical engineering at Stanford University and past-president of the A.I.E.E., was made a doctor of laws by the University of California on March 23.

Harry H. Walton, has recently joined the J. M. O'Donnell Co., Philadelphia, Pa., heating and power piping contractors, to cover the Eastern Pennsylvania, New Jersey, Delaware and Maryland district. Mr. Walton has been in the engineering departments of Johns-Manville Co., John R. Livezey Pipe Covering Co. and was also connected with Navy Mine Depot at Yorktown, Va.

Thomas E. Durban has rejoined the Erie City Iron Works, Erie, Pa., to direct its sales and act as advisory engineer. Mr. Durban was formerly with the company as general manager, but resigned in 1917 to serve as major in the Ordnance Department. Since that time he has been actively engaged in consulting work and recently has been working on the Boiler Code of the A.S.M.E.

Charles H. Br[illegible]nley, formerly an associate editor of *Power* and more recently manager of the engineering sales division of the S. F. Bowser & Co., Inc., Fort Wayne, Ind., has had his department augmented by the addition of the department of industrial sales, lubrication and filtration, dry cleaning, and railroad and government. He will be assisted in the work of the department by I. L. Walker, manager of dry cleaning sales, and E. M. Harshbarger, manager of railroad and government sales.

Obituary

I. B. Sager, of the St. Louis & Suburban Railway Co. and the East St. Louis Light & Power Co., died at the age of 68 on March 20, at his home in East St. Louis. As a pioneer, Mr. Sager built East St. Louis' first light and power plant in 1889. The plant was on the Mississippi River front and was intended primarily to furnish current to freight depots and railroad offices along the levee. Later the service branched out to include street lighting. When the East St. Louis & Suburban interests bought his power plant, Mr. Sager joined its organization and remained a member of it until his death.

Society Affairs

The Baltimore Section of the A.I.E.E. will hear a paper "Power From Waste Fuel," by Messrs. Coulter and Schnure, at its April 17 meeting to be held at Sparrows Point, Md.

The Cincinnati Section of the A.S.M.E. will hear H. C. Blackwell, vice-president of the Union Gas & Electric Co., speak on the "New Miami Fort Station of the Union Gas & Electric Co." at its April 23 meeting.

The Western Washington Section of the A.S.M.E. will hold its April 17 meeting at Bellingham. "Western Washington Coal and Its Use," will be one of the subjects of the meeting, and Mr. Krobbe will speak on "Portland Cement Grinding."

The Metropolitan Section of the A.S.M.E., Petroleum Division will hold a meeting at the Engineering Building, 29 West 39th St., after a dinner at the Building Trades Association, 30 West 33d St., New York City, on April 9. A paper of interest to *Power* readers will be given by W. F. Parish and W. B. Smith Whaley on "Prevention of Explosions in Air Receivers."

Trade Catalogs

Fuses — Trico Fuse Manufacturing Co., Milwaukee, Wis. "Kantar" Fuses is the title of a leaflet on these non-renewable cartridge fuses.

Oil Circuit Breakers—Condit Electrical Manufacturing Co., South Boston, Mass. Leaflet describing type FO-40 oil circuit breakers for 1,000,000 kva. and under.

Motor Maintenance Equipment—The Martindale Electric Co., 11711, Detroit, Mich. Catalog No. 6 covers commutator slotting and grinding equipment, motor-maintenance specialties, and is well illustrated.

Engines, Oil—De La Vergne Machine Co., 947 East 138th St., New York City. Pamphlet "The Relation of Power Costs to Profits," tells of savings by the use of this make of engine; Bulletin "De La Vergne Vertical Diesel Oil Engine," describes the advantages of this type of engine.

Cranes, Locomotive—American Hoist & Derrick Co., St. Paul, Minn., "American Locomotive Cranes, for Handling Materials Economically with Hook, Grab or Magnet," is the title of a catalog recently published. Well illustrated and full of descriptive data, the catalog should recommend itself to users of this equipment.

Fans—Clarage Fan Co., Kalamazoo, Mich. Reference Book No. 52, "Clarage New Type HV Fan," beside descriptive matter and photos, gives numerous tables of performance and dimensions.

Power Plant Specialties—The Hoppes Manufacturing Co., Springfield, Ohio. Catalog No. 85 describes exhaust-steam feed-water heaters, V-notch meters, live-steam feed-water purifiers, steam separators, oil eliminators and exhaust heads. It is a compact catalog and well illustrated.

Refractories—Plibrico Jointless Firebrick Co., Kingsbury at Clay St., Chicago, Ill. "Refractories and Furnace Design." This is the second edition of a treatise on the building of monolithic furnace linings with "Plibrico" furnace lining. Many photos of furnace linings both for coal and oil are shown, and instructions for the handling of this material are given.

Coming Conventions

American Electrochemical Society. Dr. Colin G. Fink, Columbia University, New York City. Convention at Niagara Falls, April 23-25.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Convention at St. Louis, April 13-17. Annual convention at Saratoga Springs, June 22-26.

American Society of Civil Engineers. George T. Seabury, 29 West 39th St., New York City. Spring meeting in Cincinnati, April 22-24.

American Society of Mechanical Engineers—Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Milwaukee, Wis., May 18-21.

American Society of Refrigerating Engineers. William H. Ross, 35 Warren St., New York City. Convention at Milwaukee, May 18-21.

American Water Works Association. W. N. Niesley, 170 Broadway, New York City. Convention at Louisville, Apr. 27-May 3.

Electric Power Club. S. N. Clarkson, B. F. Keith Bldg., Cleveland, Ohio. Convention at Hot Springs, Va., May 26-29.

Exposition of Inventions—American Institute, E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Bldg., 29 West 39th St., New York City, April 27 to May 2.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

Mid-West Power Show at Milwaukee, Wis., May 18-21. Ralph H. Cahill, care of Mid-West Power Show, City Hall, Milwaukee, Wis.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. National convention and exhibition at St. Paul, Minn., Aug. 31-Sept. 4. Annual conventions and exhibitions of state associations are scheduled as follows: **Indiana State Association** at Purdue University, Lafayette, Ind., April 20-23. W. C. Knowles, Northern Indiana Gas & Electric Co., Lafayette, Ind. **Kansas Association** at Topeka, May 6-8. J. M. Van Sant 739 Horne St., Topeka. **Pennsylvania Association** at Pittsburgh, Pa., May 15-16. Frank J. McCarron, 3647 North 11th St., Philadelphia, Pa. **Wisconsin Association** at Milwaukee, May 18-22. F. W. Horn, 256 29th St., Milwaukee, Wis. **New Jersey Association** at Atlantic City, June 4-8. H. W. Vail, 1244 Park Ave., Plainfield, N. J. **New York Association** at McAlpin Hotel, New York City, June 11-13, W. T. Meinzer, 3rd St., near Warburton, Bayside, L. I. **Iowa State Association** at Ottumwa, June 16-18. F. L. Stocker, 127 S. Elm St., Ottumwa, Iowa. **New England States Association** at Worcester, Mass., July 10-12, formerly announced June 18-20. F. L. Tyler, 32 Briggs St., Taunton, Mass. **Ohio Association** at Middleton, Ohio, June 18-20. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at New Haven, June 25-27. George F. Klopfer, 30 East Pearl St., New Haven. **Michigan Association at Muskegon,** July 15-17. Charles Unterreiner, 5522 Underwood Ave., Detroit, Mich. **Minnesota Association** at St. Paul, Aug. 24-28. C. A. Nelson, 800 22nd Ave., Minneapolis, Minn.

National District Heating Association. D. L. Gaskell, Greenville, Ohio. Sixteenth annual convention at West Baden Springs Hotel, West Baden, Ind., May 19-22.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St., New York City. Annual convention at San Francisco, June 15-20.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, National convention at Hotel Winton, Cleveland, Ohio, May 6-8.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; *mine run* except Pittsburgh gas slack (*Coal Age*):

Bituminous, Net Tons	Market Quoting	Mar. 23, 1925
Pool 1	New York	$2.50@$2.85
Smokeless	Boston	1.63
Clearfield	Boston	1.75@ 2.20
Somerset	Boston	1.90@ 2.35
Kanawha	Columbus	1.40@ 1.60
Hocking	Columbus	1.35@ 1.60
Pittsburgh	Pittsburgh	1.75@ 1.90
Pittsburgh gas slack	Pittsburgh	1.30@ 1.40
Franklin, Ill.	Chicago	2.25@ 2.50
Central, Ill.	Chicago	1.90@ 2.00
Ind. 4th Vein	Chicago	2.00@ 2.25
West Ky.	Louisville	1.25@ 1.50
S. E. Ky.	Louisville	1.25@ 1.50
Big Seam	Birmingham	1.50@ 2.00
Anthracite, Gross Tons		
Buckwheat No. 1.	New York	$2.00@$3.00
Buckwheat No. 1.	Philadelphia	2.50
Birdseye	New York	1.40@ 1.60

FUEL OIL

New York—April 2, light oil, tank-car lots; 28@34 deg. Baumé, 6c. per gal.; 36@40 deg., 6¼c. per gal., f.o.b. Bayonne, N. J.

St. Louis — Mar. 25, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.90 per bbl.; 26@28 deg., $1.95 per bbl.; 28@30 deg., $2.00 per bbl.; 30@32 deg., $2.05 per bbl.; 32@36 deg., gas oil. 5¼c. per gal.; 38@40 deg., 6c. per gal.

Pittsburgh—Mar. 31, f.o.b. local refinery; 30@34 deg. fuel oil, 6½c. per gal.; 36@40 deg., fuel oil, 6¾c. per gal.

Dallas—April 1, f.o.b. local refinery, 26@30 deg., $1.90 per bbl.

Philadelphia—Mar. 25, 28@30 deg., $2.52@$2.583 per bbl.; 18@22 deg., $2.42@$2.483; 13@16 deg., $2.20½@ $2.268 per bbl.

Boston—Mar. 30, tank-car lots, f.o.b. heavy oil, 12@14 deg., Baumé, 4¾c. per gal.; light oil, 28@32 deg. Baumé, 6c. per gal.

Cincinnati — Mar. 24, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6¾c. per gal.; 30@32 deg., 7c. per gal.

New Plant Construction

Calif., Holtville—Imperial Ice and Delivery Co., awarded contract for the construction of a 60 x 90 ft. ice manufacturing plant, at 5th and Walnut Sts., to Gay Engineering Corp., 2650 Santa Fe Ave., Los Angeles. $50,000.

Calif., San Francisco—W. B. Wagnon, 325 Bush St., awarded contract for the construction of a 4 story, theater and office building at Hyde and Market Sts., to R. McLeran & Co., Hearst Bldg., $1,500,000. A. Pantages, Pantages Theater Bldg., is lessee.

Fla., Miami Beach (Miami P. O.)—Royal Palm Ice and Refrigerating Co. awarded contract for the construction of an ice plant to G. S. Symmonite Construction Co., $175,000. Plant will be equipped with oil engines. Owner also awarded contract for plant at Hialeah, $250,000, and will install oil engines.

Ill., Chicago—Coolidge & Hodgson, 134 South La Salle St., Engrs. and Archts., will soon award contract for the construction of a group of nine, 6 story hospital and medical buildings, for the University of Chicago, 230 Clarke St. Estimated cost $2,000,000.

Ill., Peoria—City, H. Frankel, 631 South Adams St., chairman of commission, plans an election April 21 to vote $150,000 bonds for the construction of a municipal market, with refrigeration system. Engineer and architect not selected.

Ill., Peru—City, voted $90,000 bonds to rebuild municipal power plant, to supply electricity and water.

Ill., Riverdale—Acme Steel Goods, C. S. Traer, plant mgr., is in the market for various sized motors for new strip steel mill.

Ia., Corning—City, plans the construction of an electric light plant.

La., New Orleans — Guarantee Realty Co., 910 Graicer Pl., is having plans prepared for the construction of a 10 story hotel at South Rampart St. and University Pl. Estimated cost $1,000,000. J. S. Joy, 2001 West Pershing Pl., Chicago, Ill., is architect.

La., New Orleans — E. M. Loeb, 618 Magazine St., W. B. Spencer 321 St. Charles St., A. F. Commagere, and J. S. Joy, 2001 West Pershing Rd., Chicago, Ill., are having plans prepared for the construction of a 16 story office building, at Baronne and Common Sts. Estimated cost $1,250,000. J. S. Joy, 2001 West Pershing Rd. Chicago, Ill., is architect.

Mich., Detroit—C. N. Agree, 1333 Book Bldg., will receive bids until April 10, for the construction of a 14 story hotel addition, with steam heating system, for the Whittier Hotel, Burns Ave.

Mich., Detroit — Detroit Metropolitan Corporation, c/o E. A. Loveley, Stormfelz-Loveley Co., Washington Blvd. Bldg. awarded contract for the construction of a 12 story, office and theatre building with steam heating system, on Bagley Ave., to Lundoff-Bicknell Co., B. F. Keith Bldg., Cleveland, O. Estimated cost $4,000,000.

Mich., Detroit — C. A. Gable, et al., of Detroit Hockey Club, c/o G. W. Graves, 233 John R. St., Archt. plan the construction of a 2 story, hotel and recreation building, with steam heating system and natatorium, on Woodward Ave. Estimated cost $2,000,000.

Minn., Winona—Bd. of Municipal Works, H. Magnus, Secy., will receive bids until April 8 for waterworks improvements, including Contract A, pumping station, Contract F, air compressors and air lift pump plant, etc. Estimated cost $75,000. Alvord, Burdick & Howson, 8 Dearborn St., Chicago, Ill., are engineers.

Mo., Springfield—J. T. Woodruff, Woodruff Bldg., awarded contract for the construction of a 4 story hotel, to G. C. Caudwell & Sons, Woodruff Bldg. Estimated cost $650,000.

Neb., Spencer—North Nebraska Power Co. plans the construction of a power plant.

N. Y., Brooklyn—B. Sackheim, Archt., 166 Montague St., is preparing plans for a hotel on Clinton St. Estimated cost $1,000,000. Owner's name withheld.

N. Y., Coney Island (Brooklyn P. O.)—American Hotel Co. 25 West 45th St., is having plans prepared for the construction of a 17 story hotel at 29th St. and the Boardwalk. G. B. Post & Sons, 10 Park Ave., are architects.

N. Y., Dexter—Town, voted $90,000 bonds for the construction of a waterworks system, including well, pump, etc. W. T. Field, Watertown, is engineer.

N. Y., New York—Lerner Blouse Corp., c/o C. N. Whinston, Archt., 2 Columbus Circle, is having plans prepared for the construction of an 18-story office building, including steam heating system, on Trinity Place.

N. Y., New York—H. Lucas, 101 Park Ave., awarded contract for the construction of an apartment house on East 57th St., to Todd Robertson and Todd Engineering Co., 347 Madison Ave. Estimated cost $1,500,000. Steam heating system to be installed.

N. Y., New York—Washington Square Holding Co., c/o Dentsch & Schneider, 35 Maiden Lane, archts., is having plans prepared for the construction of 15 story apartment at 32 Washington Sq. West. Estimated cost $850,000.

N. Y., Sackets Harbor — Town, voted $70,000 bonds for the construction of a waterworks system, including well, pumps, tank on tower, etc. W. T. Field, Watertown, is engineer.

N. D., Carrington—City, is in the market for 300 gal. centrifugal pump, and 25 hp. engine. L. P. Wolff, 903 Globe Building, is engineer.

O., Cleveland—City, c/o A. K. Hoare, will receive bids until April 19th for one, 300 kw., 125 v., 1,250 r.p.m., d.c. and one, 300 kw., 250 v., 1,250 r.p.m., d.c. generator sets.

O., Cleveland—Cleveland Electric Illuminating Co., c/o J. Wolf, Illuminating Bldg., awarded contract for the foundation of a generating station, at Avon Beach to Hunkin-Conkey Construction Co., Hunkin-Conkey Bldg., Total estimated cost $10,000,000.

Okla., Collinsville—City, will hold an election April 7th, to vote $125,000 bonds for mains, new pumping equipment, including motor driven pumps and repairs to present plant, also, to connect with Spavinaw pipe line system of Tulsa. Holway Engineering Co., Wright Bldg., is engineer.

Okla., Idabel—City will soon receive bids for waterworks improvements, including motor driven pumps, oil engine, etc. Estimated cost $23,000. V. V. Long & Co., Oklahoma City, are engineers.

Okla., Prague—City, H. W. Hartman, Mayor, voted $22,000 bonds for well with air lift equipment, new air compressor, etc. Holway Engineering Co., Wright Bldg., Tulsa, is engineer.

Okla., Vici—Town, W. G. Exhart, mayor, plans an election to vote $20,000 bonds for the construction of a waterworks system, including deep well pump, motor, etc. Gantt-Baker Co., 1116 West Main St., Oklahoma City, is engineer.

Pa., Philadelphia—Mutual Trust Co., 4th and Chestnut Sts., is having preliminary plans prepared for the construction of an 18 story office building at Sydenham and Walnut Sts. Heacock & Hokenom, 1211 Chestnut St. and Ballwaer Co., 12 Chestnut St., are engineers.

Tex., Big Springs—City plans an election April 7 to vote $30,000 bonds for extensions to waterworks system, including pumping equipment. J. W. Middleton, is secretary. Engineer not selected.

Tex., Dallas—Fracer Brick Co., 810 Central Bank Bldg., is in the market for a 50 hp. steam engine (used.)

Tex., Dallas—J. L. McNees, Santa Fe Bldg., is in the market for 125 hp. boiler and 100 hp. steam engine.

Tex., Lubbock—W. G. Swenson, G. T. Scales, A. F. Holt, Haskell, awarded contract for the construction of a 25 ton ice plant, here, to J. B. Maxey. $35,000.

Tex., Mission — Valley Electric & Ice Plant, will soon receive bids for the construction of an electric power plant, with equipment. Estimated cost $30,000. Private plans. Owner is in the market for equipment.

Tex., Panhandle — City, C. E. Deahl, Mayor, voted $35,000 bonds for installation of engine in electric power plant, and other improvements. Engineer not selected.

Tex., Richland Springs—San Saba Light & Ice Plant, will soon receive bids for the construction of a cold storage plant. Estimated cost $35,000. Private plans. Machinery will be required.

Tex., Robert Lee — City, Chamber of Commerce, is having plans prepared for the construction of a 20 ton ice plant. Estimated cost $30,000. Private plans. Also plans an election to vote $35,000 bonds for the construction of a waterworks system, including pumping equipment, etc. Engineer not selected.

Wash., Olympia — R. F. Brown, Centralia, applied to the supervisor of hydraulics for a permit to appropriate 250 cu.ft. of water per sec. from the Campus River, in Skamania County. Owner plans the construction of a 20,000 hp. hydro electric plant, with dam. Estimated cost $1,500,000!

Wash., Port Angeles — Northwestern Power & Light Co., applied for permit to take 600 sec. ft. of water in the Elwha River, for the development of a power plant, of 7,500 hp. with an impounding dam. Estimated cost $800,000.

Wash., Seattle — Olympus Holding Co., Walker Bldg., Seattle, awarded contract for the construction of a 10 story hotel, at 4th and Virginia Sts., to Stephen Berg, 3402 Woodland Ave. Estimated cost $750,000.

Wis., Manawha—Village, J. C. Kinsman, Clk., will receive bids until April 15 for the construction of a waterworks system, including 2 centrifugal pumps, 500 g.p.m., at 180 ft., direct connected to 220, three phase 60 cycle, 1,750 r.p.m. motors, valves, mains, etc. McMahon & Clarke Engineering Co., Menasha, are engineers.

Wis., Marinette—North American Power Co., c/o Milwaukee Electric Railway & Light Co., Public Service Bldg., Milwaukee, plans hydro electric developments at Pernee dam and Chappee Rapids on the Menominee River, near here. G. G. Post, c/o owner, is engineer.

Wis., Milwaukee — Plankinton Packing Co., Muskego Ave. and Canal St., awarded contract for the construction of a 4 story, cooler and market at Muskego Ave. & Market St., to Dahlman Construction Co., 456 Broadway. Estimated cost $350,000.

B. C., Vancouver—American Syndicate, c/o A. H. Allen, Devonshire Apts., will receive bids in about six weeks for the construction of a 12 story apartment hotel. Estimated cost $800,000. F. C. Mahon, Seattle, Wash., is architect.

Ont., Arnprior — Hydro Electric Power Commission of Ontario, 190 University Ave., Toronto, plans a hydro power development, on the Ottawa River, at Roche Fond, near here; to provide 66,000 hp. Estimated cost $5,000,000. Equipment will include turbines, generators, cranes, compressors, motors, pumps, etc. F. A. Gaby, 190 University Ave., Toronto, is chief engineer.

Ont., Fort William—City plans the construction of sewage pumping station in connection with improvements in eastern end of city. Estimated cost $40,000. C. B. Symes, City Hall, is engineer.

Ont., Mimico—Town, is having plans prepared for the construction of a pumping station, including pumphouse, centrifugal, 3 stage, electric pumps, filters, etc. Estimated cost $125,000. James, Proctor & Refern, 36 Toronto St., Toronto, are engineers.

Ont., Port Arthur—City, plans the construction of pumping station, with equipment, including centrifugal electric, 3 stage pumps. Estimated cost $15,000. J. Antonisen, City Hall, is engineer.

Ont., Toronto—Elias Rogers Co., Ltd., 85 Bay St., plans the installation of a coal handling plant, including electric motors, elevating equipment, etc. Estimated cost $50,000. John Hole, 167 Yonge St., is engineer.

Ont., Toronto—Johnson Super Fuel Oil Burners, 150 King St., is in the market for fuel oil storage tanks, from 100 to 5,000 gal. capacity, also, 25 cycle, single phase, a.c. electric motors, from ½ to 1 hp., 110 and 220 v.

Que., Carillon—E. N. Robert, 263 St. James St. Montreal, is having plans prepared for a hydro-electric development, here. Estimated cost $50,000,000. J. A. Fleet, 263 St. James St., Montreal, is engineer.

Que., Drummondville—Southern Canadian Power Co., Montreal, plans enlargements to plant, here, including installation of 2, vertical water wheel driven generators, 600 k.v.a. capacity, 60 cycle, 4,000 v.

Que., Ste. Anne de Beaupre — Energie Electric de Rinere des Chines, plans the construction of a power plant. Estimated cost $50,000.